Black Swans, Dragons-Kings and PREDICTION

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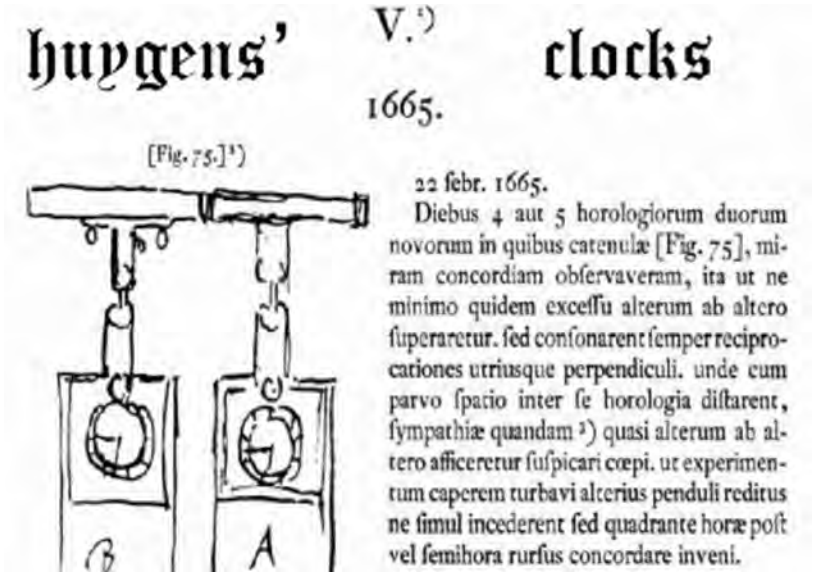
SYNCHRONISATION AND COLLECTIVE EFFECTS IN EXTENDED STOCHASTIC SYSTEMS



huygens' V.[5] clocks

1665.

[Fig. 75.][1])

22 febr. 1665.

Diebus 4 aut 5 horologiorum duorum novorum in quibus catenulæ [Fig. 75], miram concordiam obſervaveram, ita ut ne minimo quidem exceſſu alterum ab altero ſuperaretur. ſed conſonarent ſemper reciprocationes utriusque perpendiculi. unde cum parvo ſpatio inter ſe horologia diſtarent, ſympathiæ quandam [2]) quasi alterum ab altero afficeretur ſuſpicari cœpi. ut experimentum caperem turbavi alterius penduli reditus ne ſimul incederent ſed quadrante horæ poſt vel ſemihora rurſus concordare inveni.

Fireflies

(Prof. R.E. Amritkar)

Earthquake-fault model

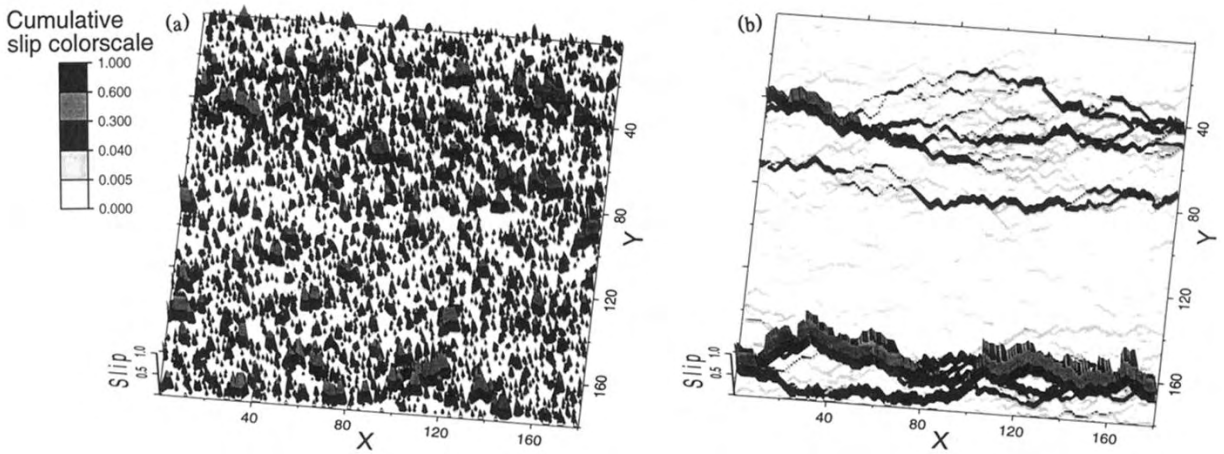
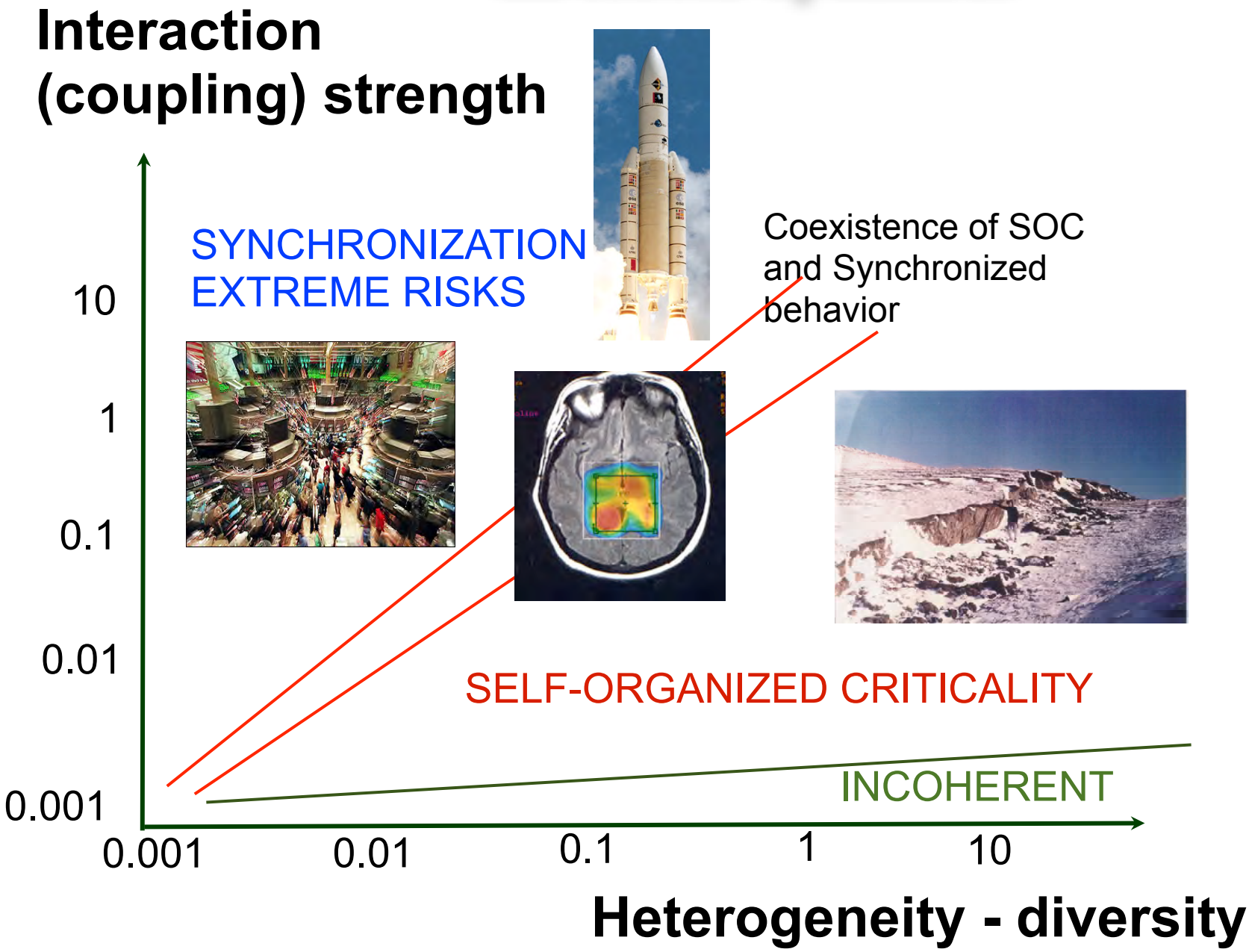


FIG. 1. Evolution of the cumulative earthquake slip, represented along the vertical axis in the white to black color code shown above the picture, at two different times: (a) early time and (b) long time, in a system of size $L=90$ by $L=90$, where $\Delta\sigma=1.9$ and $\beta=0.1$.

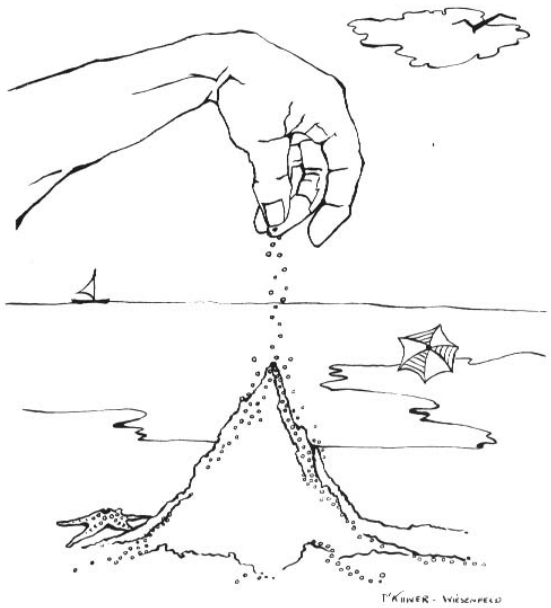
Miltenberger et al. (1993)

Generic diagram for coupled agents with threshold dynamics

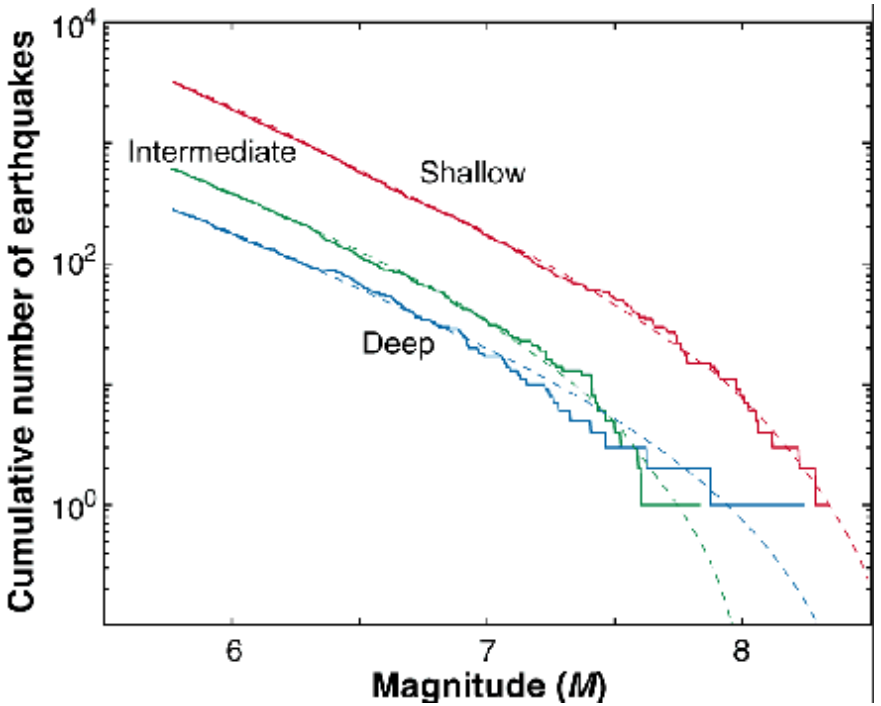


“fat-tail events” ?

Self-organized criticality

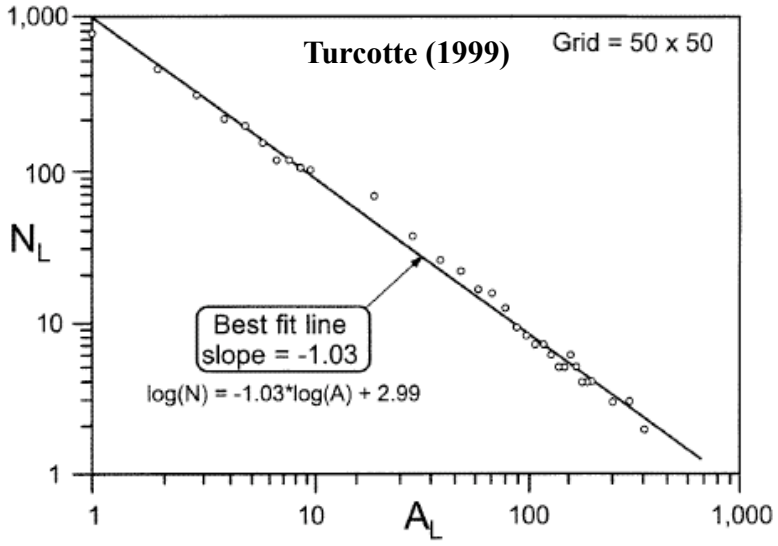


(Bak, Tang, Wiesenfeld, 1987)



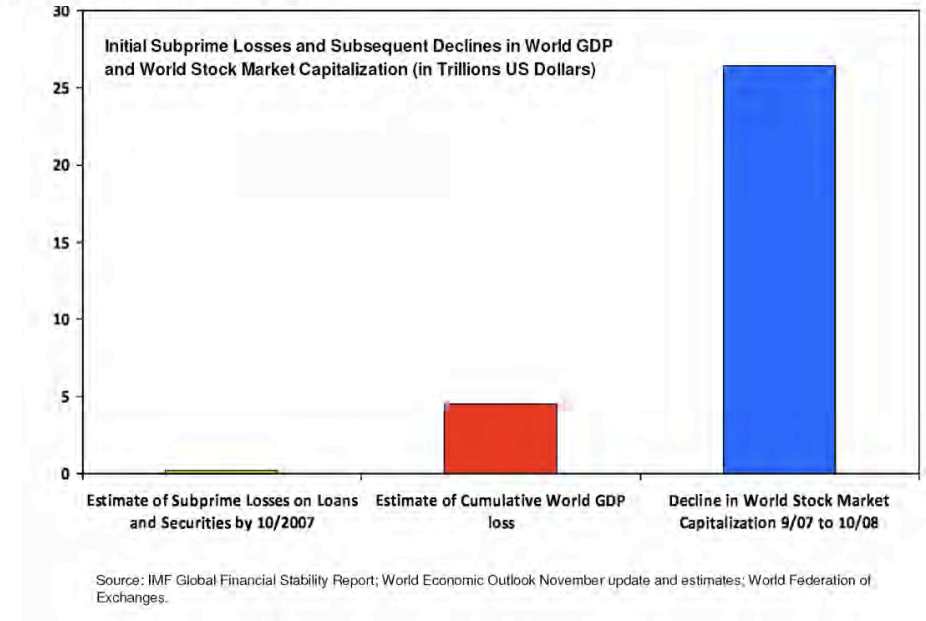
Earthquakes Cannot Be Predicted

Robert J. Geller, David D. Jackson, Yan Y. Kagan, Francesco Mulargia
Science 275, 1616-1617 (1997)



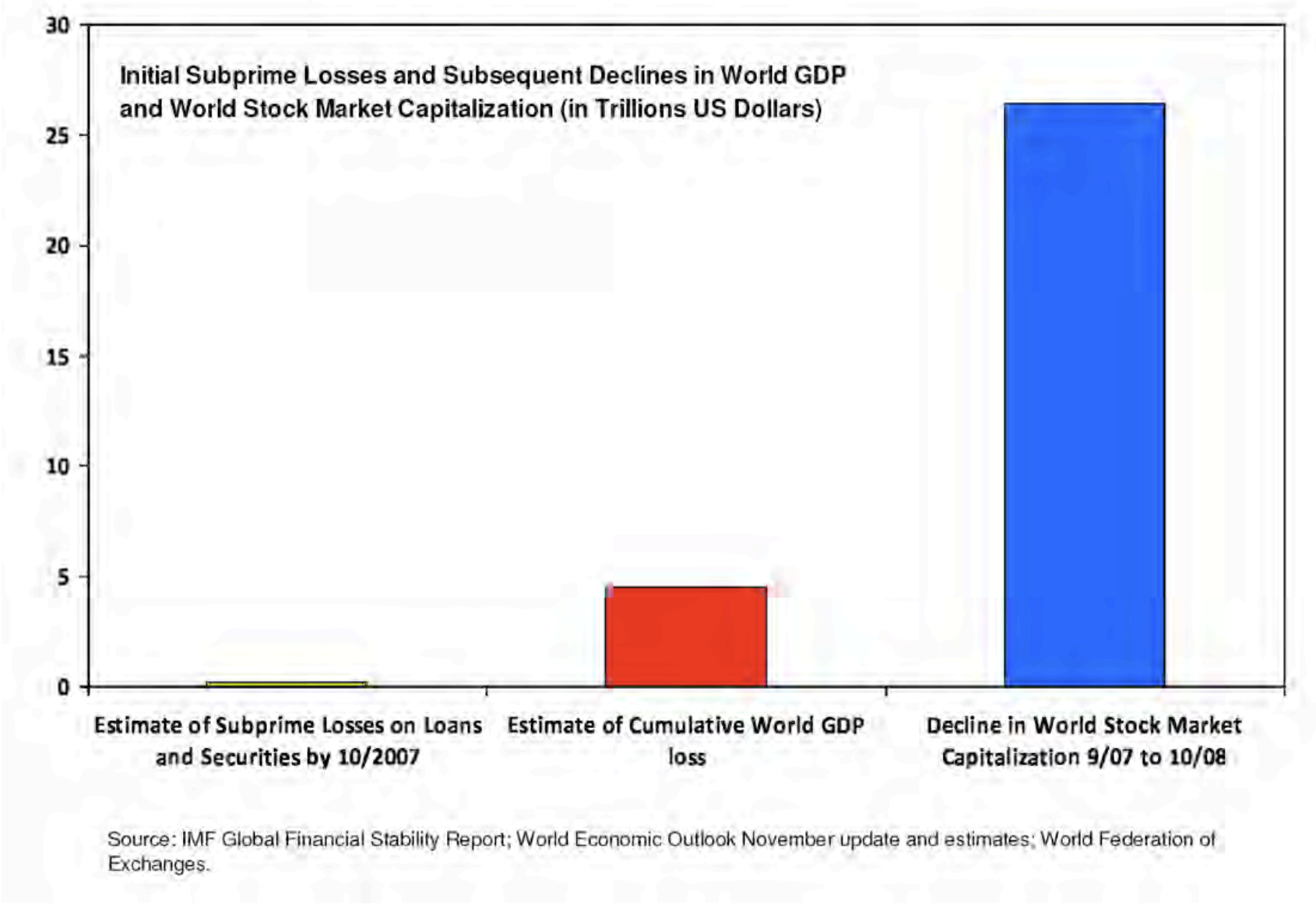
Black Swan story

- Unknown unknowable event
  - ★ cannot be diagnosed in advance, cannot be quantified, no predictability
- No responsability ("wrath of God")
- One unique strategy: long put and insurance



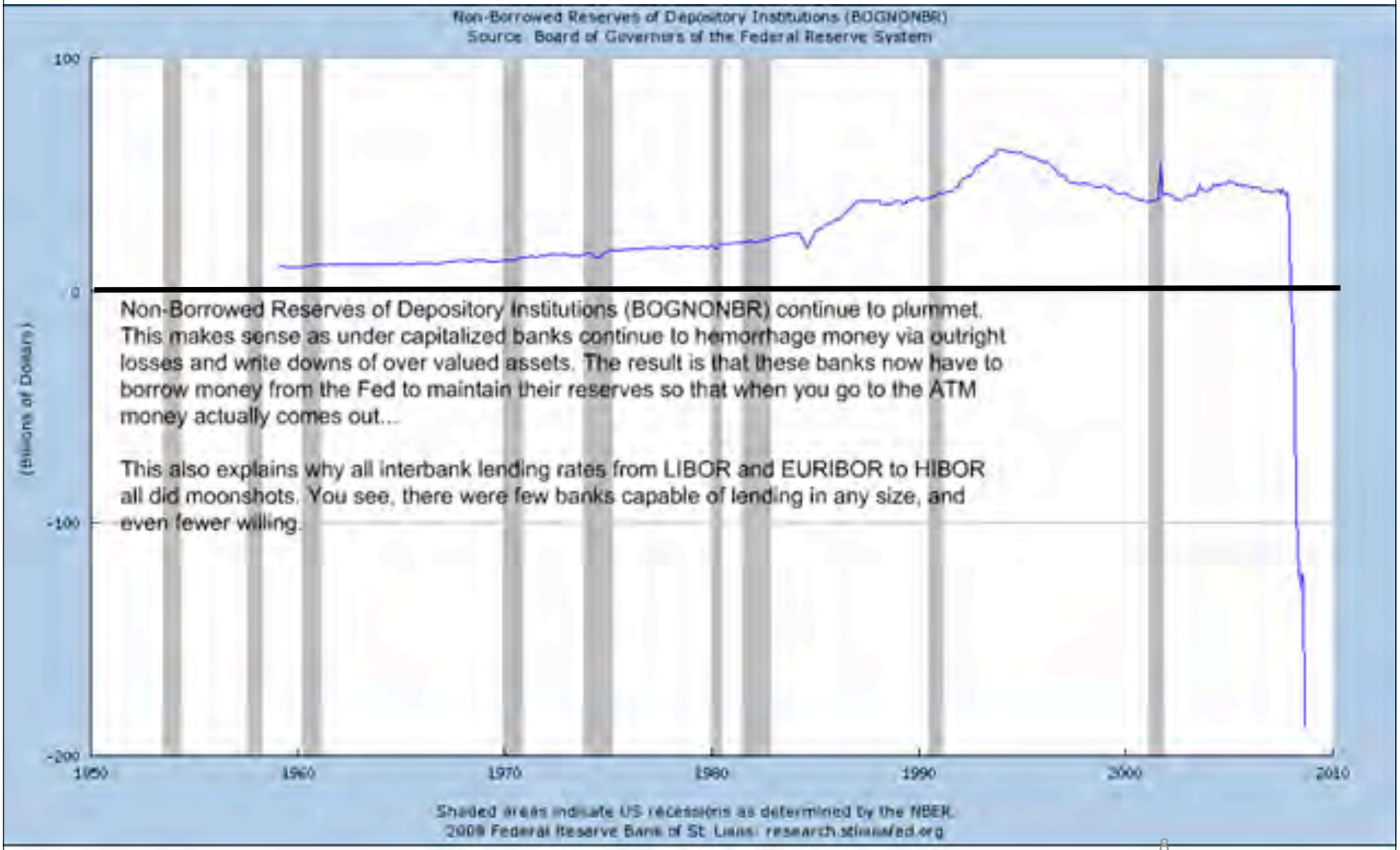
The Paradox of the 2007-20XX Crisis

(trillions of US$)

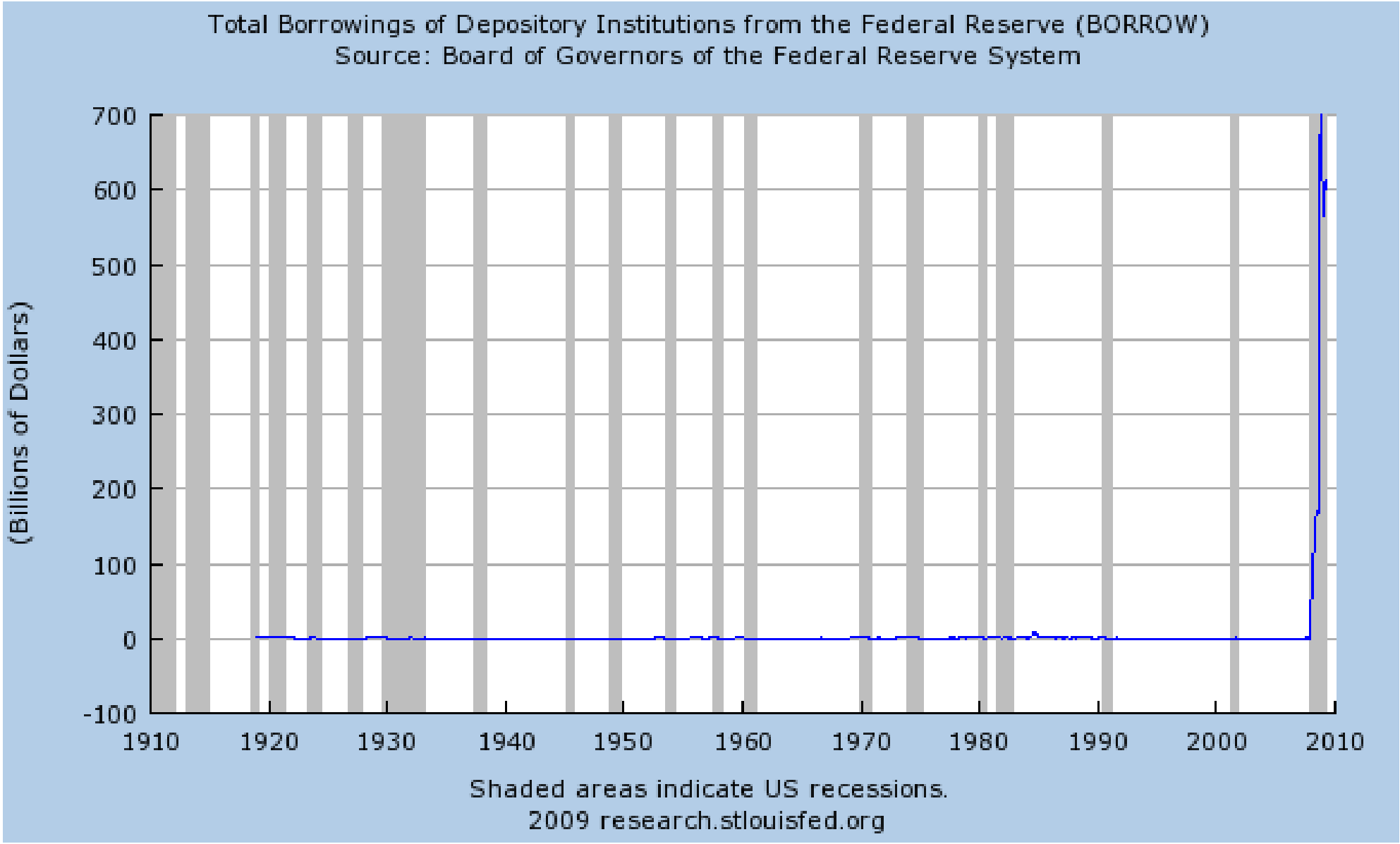


Source: IMF Global Financial Stability Report; World Economic Outlook November update and estimates; World Federation of Exchanges.

2008 FINANCIAL CRISIS



2008 FINANCIAL CRISIS



March 2009

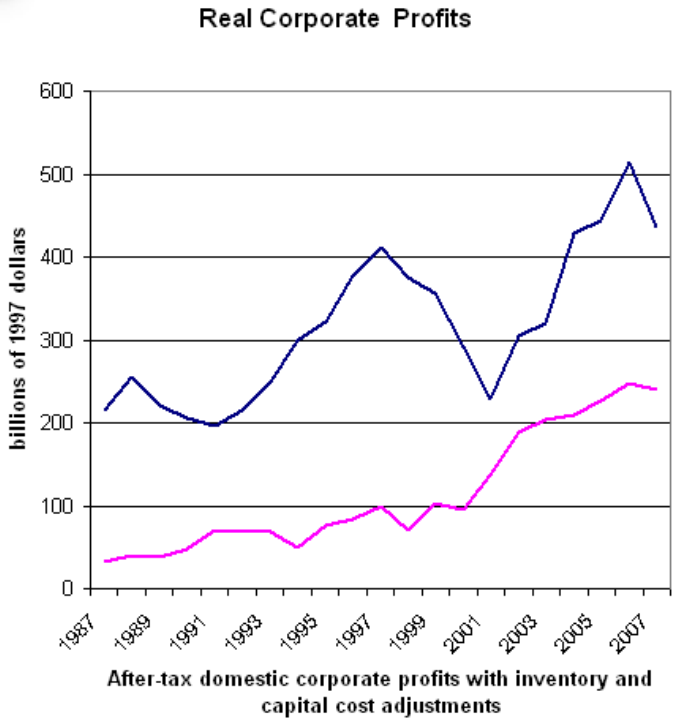
Crises are not

but

"Dragon-kings"

Dragon-king hypothesis

- Most crises are "endogenous"
  - ★ can be diagnosed in advance, can be quantified, (some) predictability
- Moral hazard, conflict of interest, role of regulations
- Responsibility, accountability
- Strategic vs tactical time-dependent strategy
- Weak versus global signals



http://www.businessweek.com/the_thread/economicsunbound/archives/2009/03/a_bad_decade_fo.html

Black Swan (*Cygnus atratus*)

Dragon-king story

Dragon-king-outlier drawdowns

↓

Require new different mechanism

↓

Follow excesses ("bubbles")

↓

Bubbles are collective endogenous excesses
fueled by positive feedbacks

↓

Most crises are "endogenous"

↓

Possible diagnostic and predictions
via "coarse-grained" metrics (forest versus trees)

Beyond power laws: 7 examples of "Dragons"

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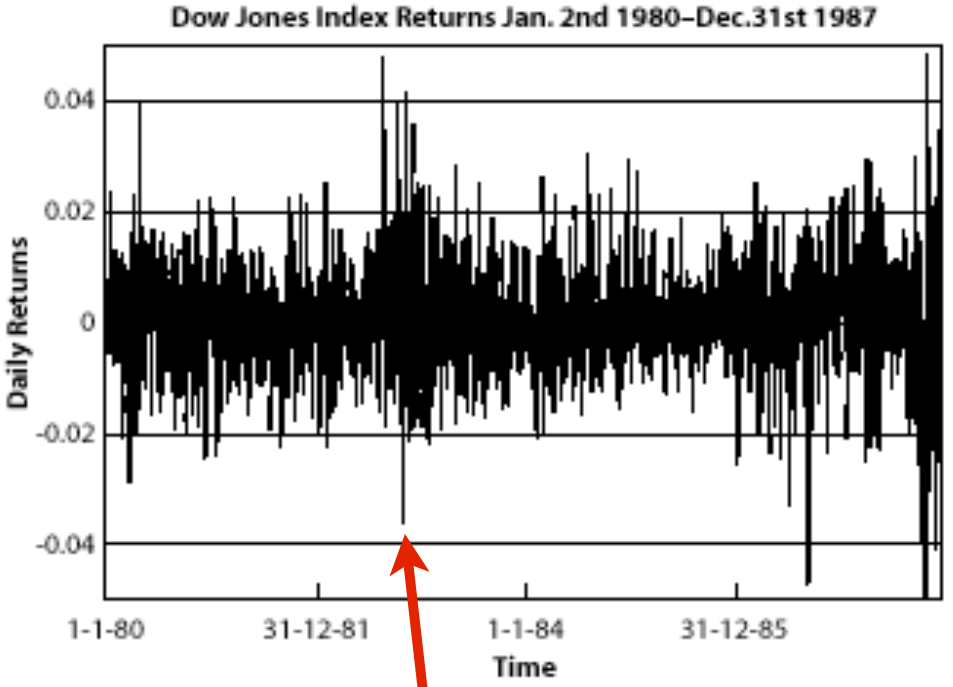
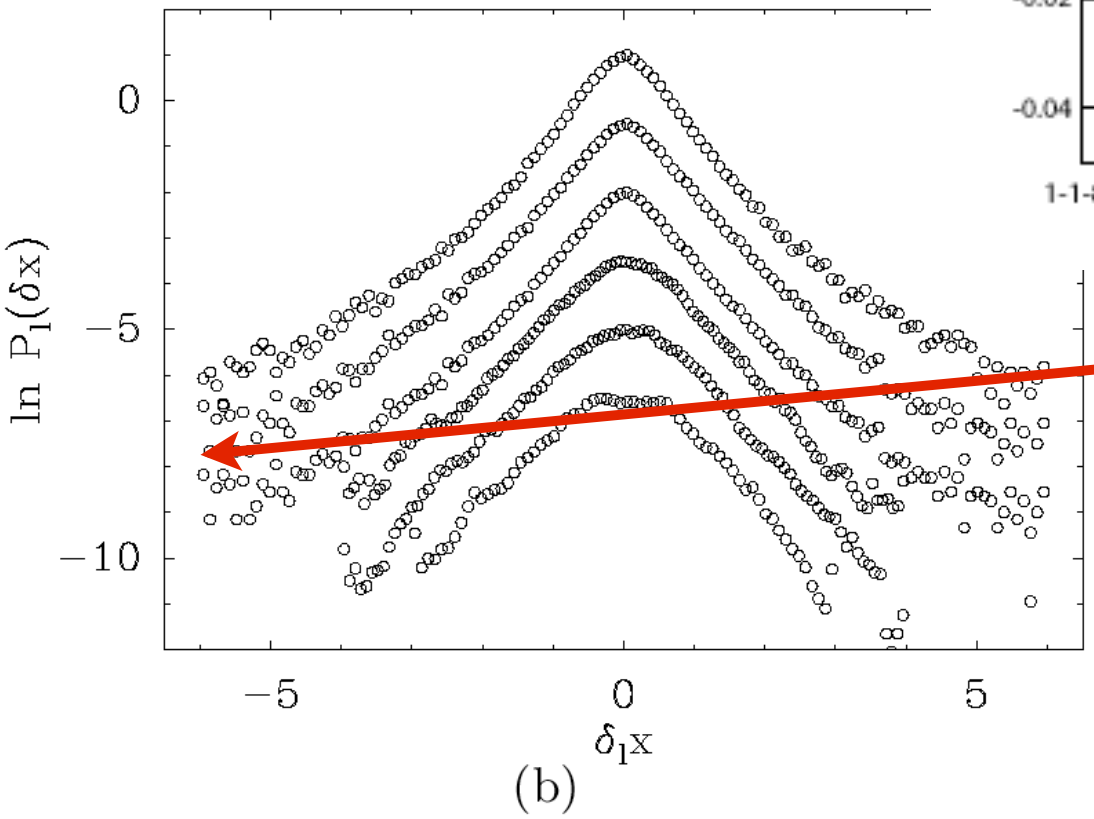
Crashes as "Black swans"?

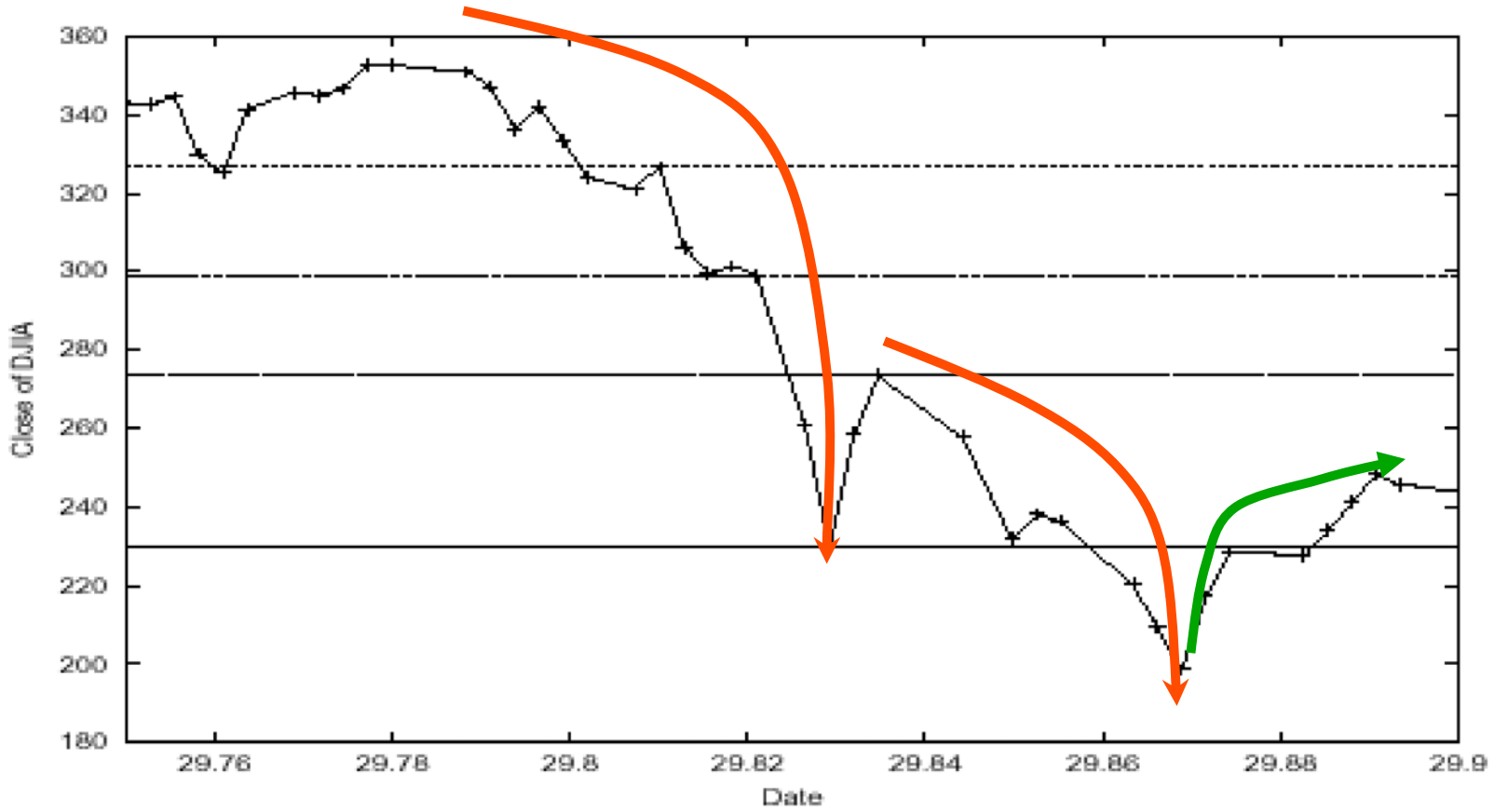
Traditional emphasis on
Daily returns do not reveal
any anomalous events



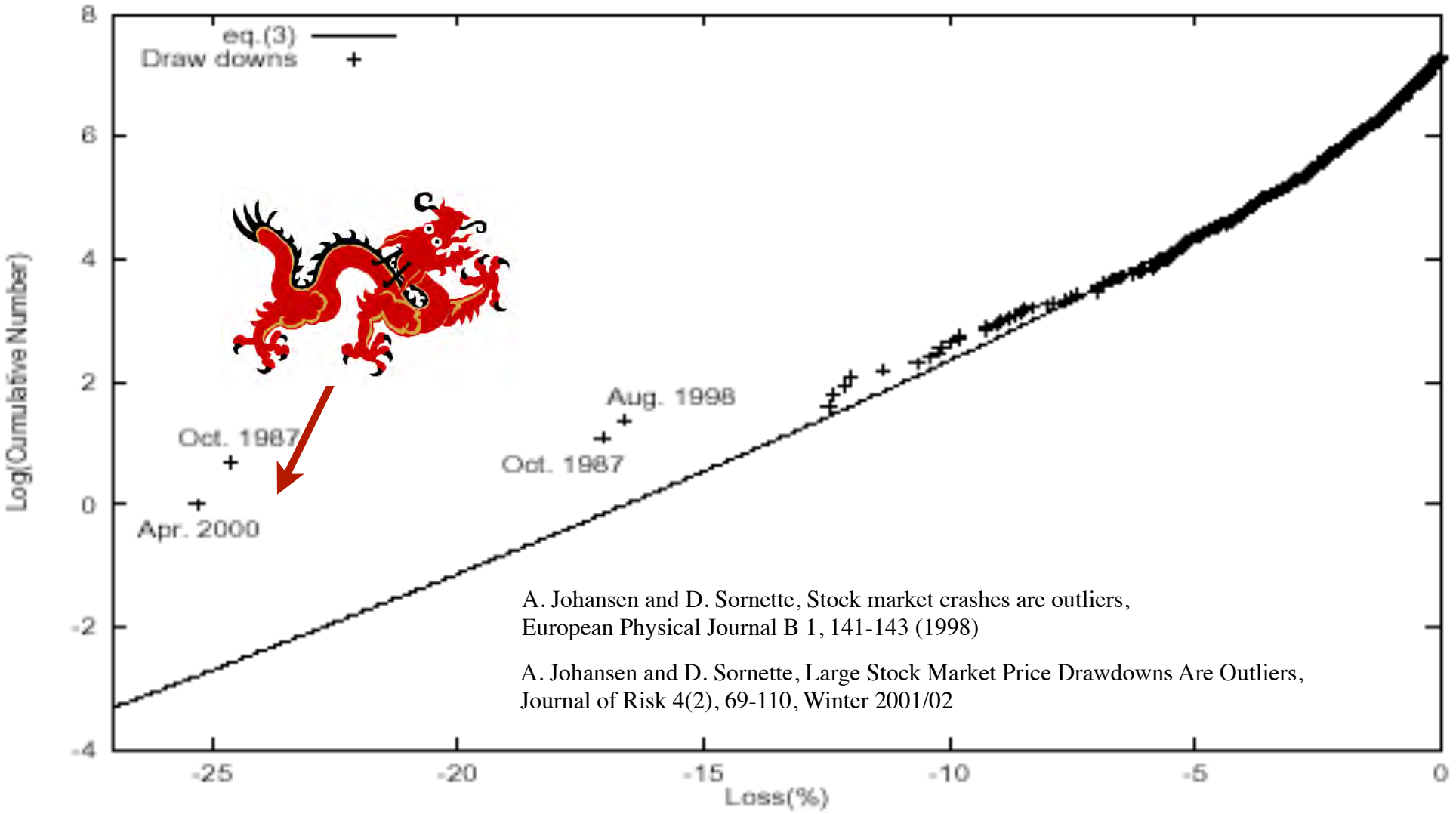


"Black swans"

Better risk measure: drawdowns



"Dragons" of financial risks



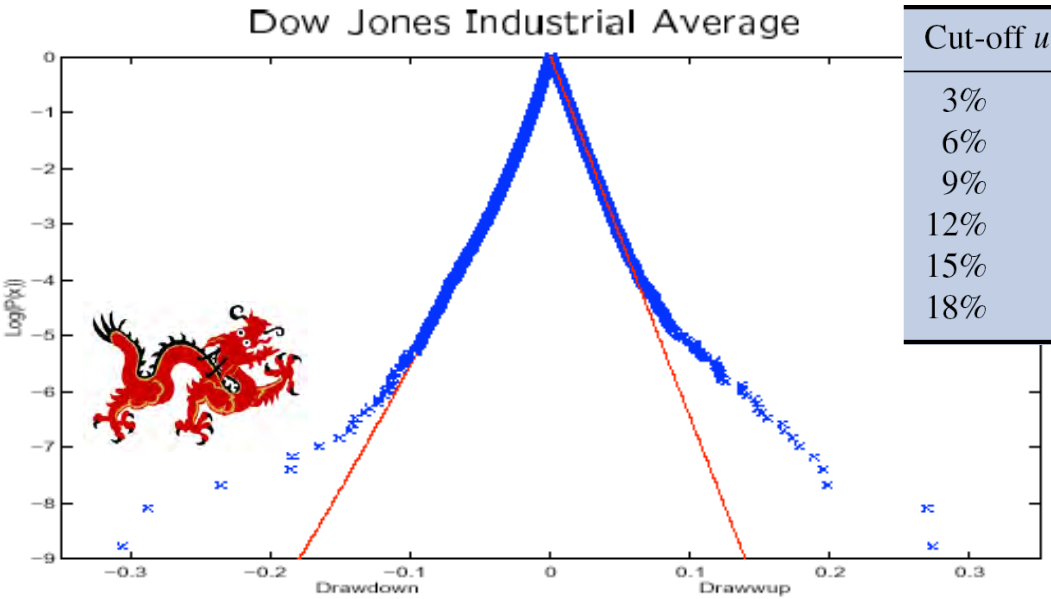
A. Johansen and D. Sornette, Stock market crashes are outliers, European Physical Journal B 1, 141-143 (1998)

A. Johansen and D. Sornette, Large Stock Market Price Drawdowns Are Outliers, Journal of Risk 4(2), 69-110, Winter 2001/02

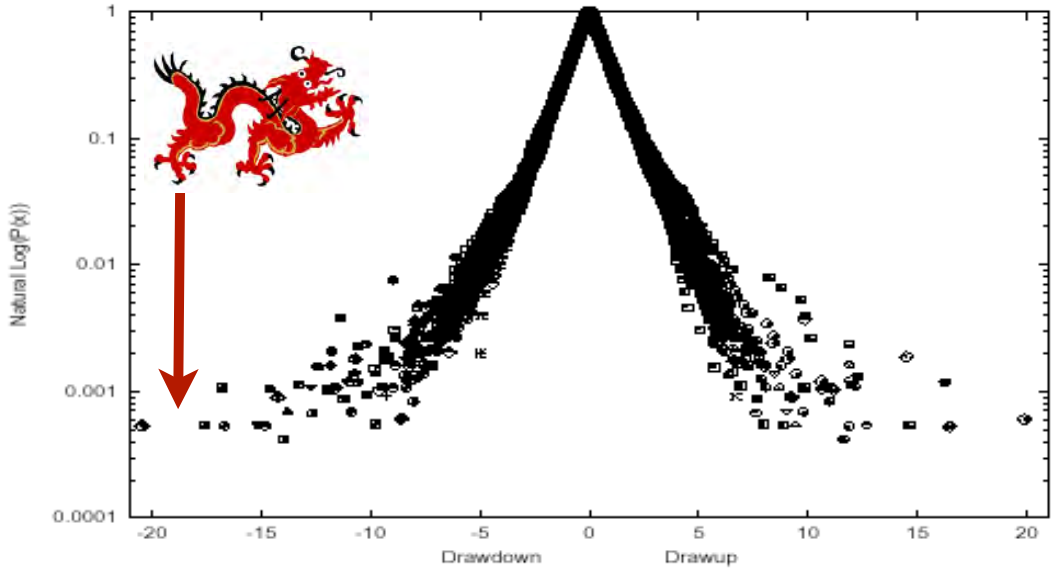
$$N(DD) = A \exp\left(-\left(|DD|/\chi\right)^{z}\right).$$

"Dragons" of financial risks

(require special mechanism and may be more predictable)



Cut-off u	Quantile	z	$\ln(L_0)$	$\ln(L_1)$	T	Proba
3%	87%	0.916, 0.940	4890.36	4891.16	1.6	20.5%
6%	97%	0.875, 0.915	4944.36	4947.06	5.4	2.0%
9%	99.0%	0.869, 0.918	4900.75	4903.66	5.8	1.6%
12%	99.7%	0.851, 0.904	4872.47	4877.46	10.0	0.16%
15%	99.7%	0.843, 0.898	4854.97	4860.77	11.6	0.07%
18%	99.9%	0.836, 0.890	4845.16	4851.94	13.6	0.02%



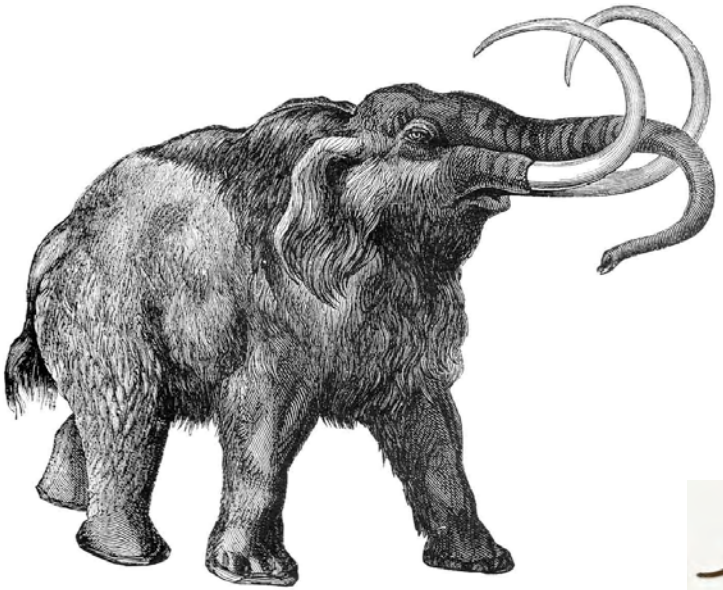
10% daily drop on Nasdaq : 1/1000 probability

1 in 1000 days => 1 day in 4 years

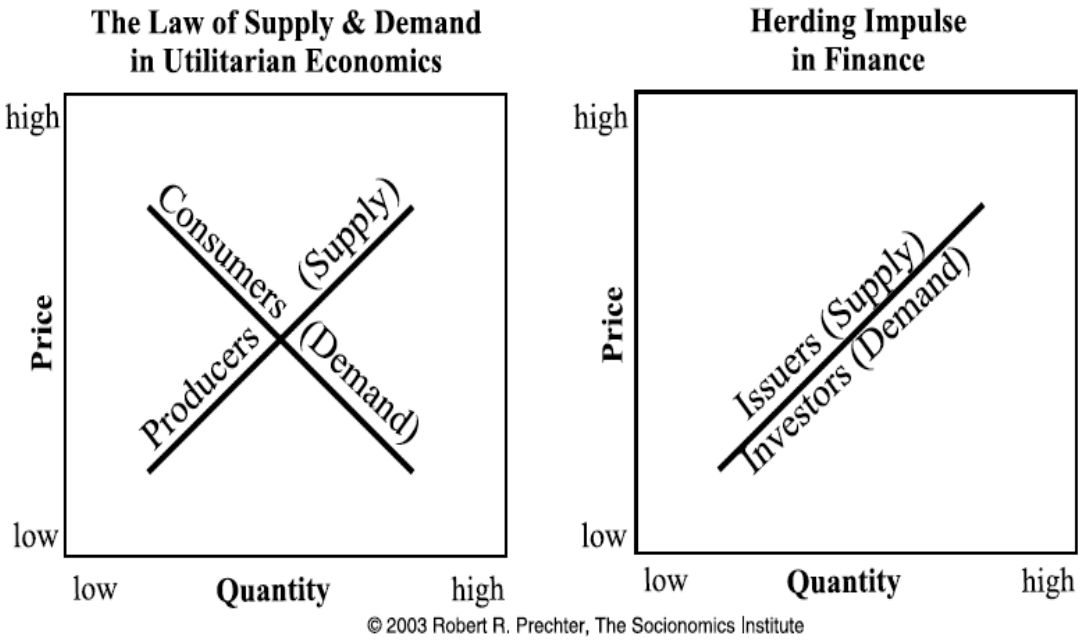
30% drop in three consecutive days?

(1/1000)*(1/1000)*(1/1000) = (1/1000’000’000)

=> one event in 4 millions years!



Positive feedbacks

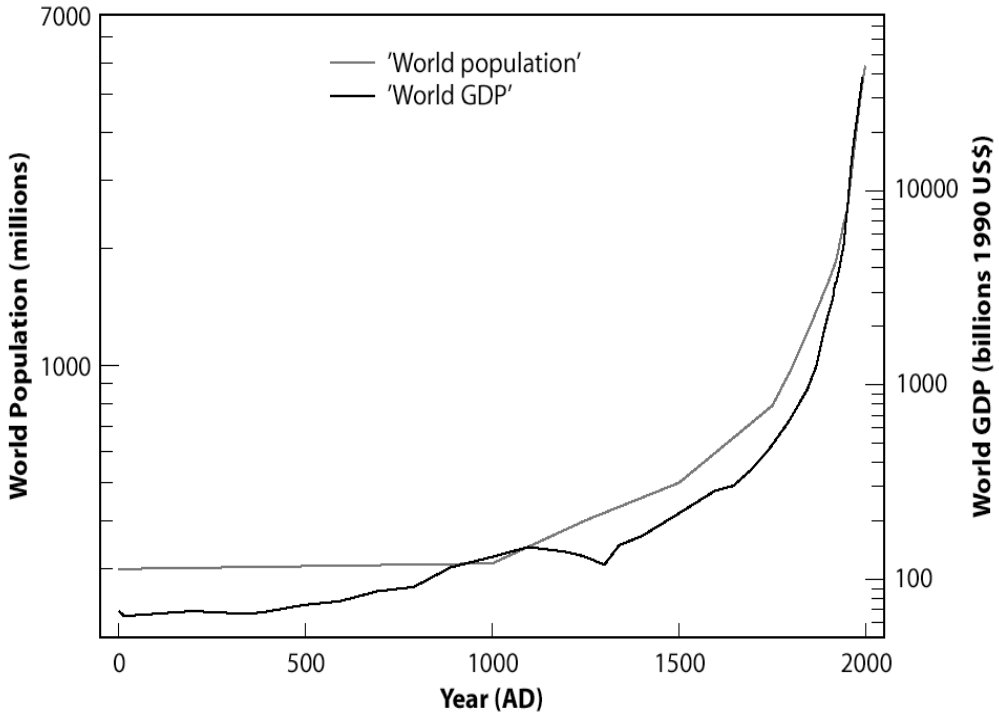


-bubble phase
-crash phase

$$\frac{dp}{dt} = cp^d$$

$$p(t) = \left(\frac{c}{m}\right)^{-m} (t_c - t)^{-m}$$

$$m = 1/(d-1) > 0 \text{ and } t_c = t_0 + mp_0^{1-d}/c.$$



Bubble preparing a crisis:
Faster than exponential
transient unsustainable
growth of price

Mechanisms for positive feedbacks in the stock market

- Technical and rational mechanisms
  1. Option hedging
  2. Insurance portfolio strategies
  3. Trend following investment strategies
  4. Asymmetric information on hedging strategies

- Behavioral mechanisms:
  1. Breakdown of "psychological Galilean invariance"
  2. Imitation(many persons)
     a) It is rational to imitate
     b) It is the highest cognitive task to imitate
     c) We mostly learn by imitation
     d) The concept of "CONVENTION" (Orléan)

Finite-time Singularity

as a result of positive feedbacks

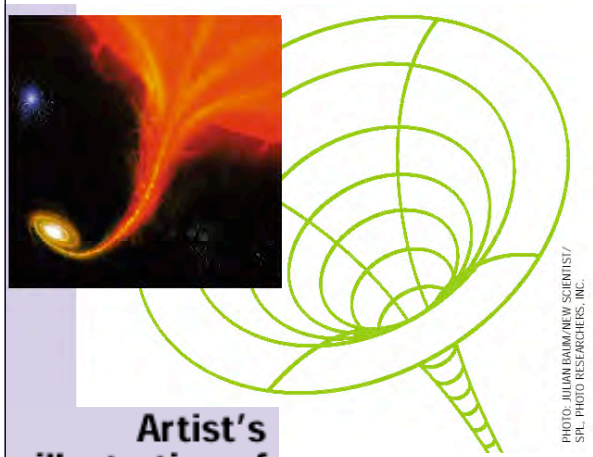


PHOTO: JULIAN BAUM/NEW SCIENTIST/ SPL, PHOTO RESEARCHERS, INC.

Artist's illustration of matter from a red giant star being pulled toward a black hole.

- Planet formation in solar system by run-away accretion of planetesimals
- PDE's: Euler equations of inviscid fluids and relationship with turbulence
- PDE's of General Relativity coupled to a mass field leading to the formation of black holes
- Zakharov-equation of beam-driven Langmuir turbulence in plasma
- rupture and material failure
- Earthquakes (ex: slip-velocity Ruina-Dieterich friction law and accelerating creep)
- Models of micro-organisms chemotaxis, aggregating to form fruiting bodies
- Surface instability spikes (Mullins-Sekerka), jets from a singular surface, fluid drop snap-off
- Euler's disk (rotating coin)
- Stock market crashes...

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Paris as a king-dragon

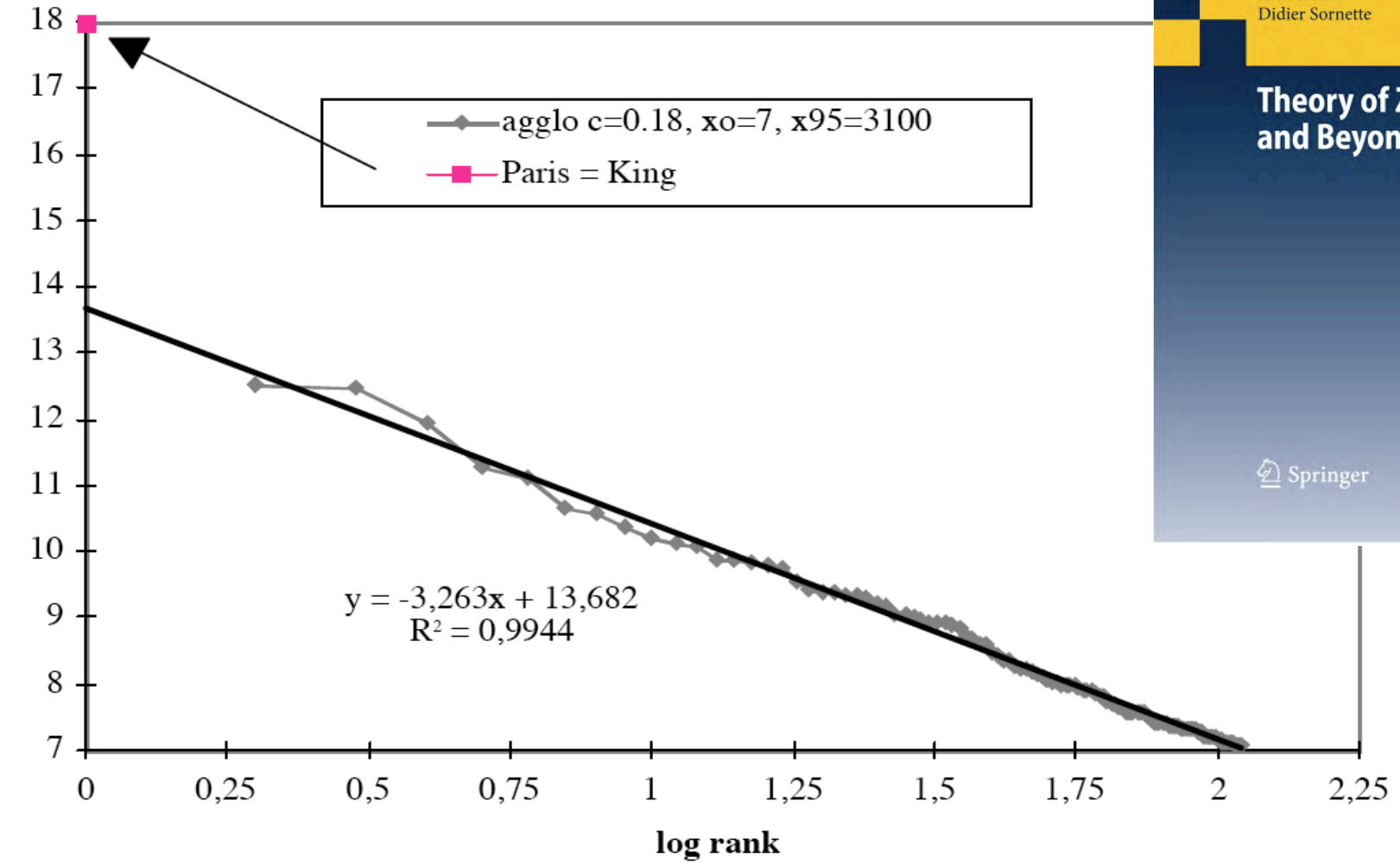
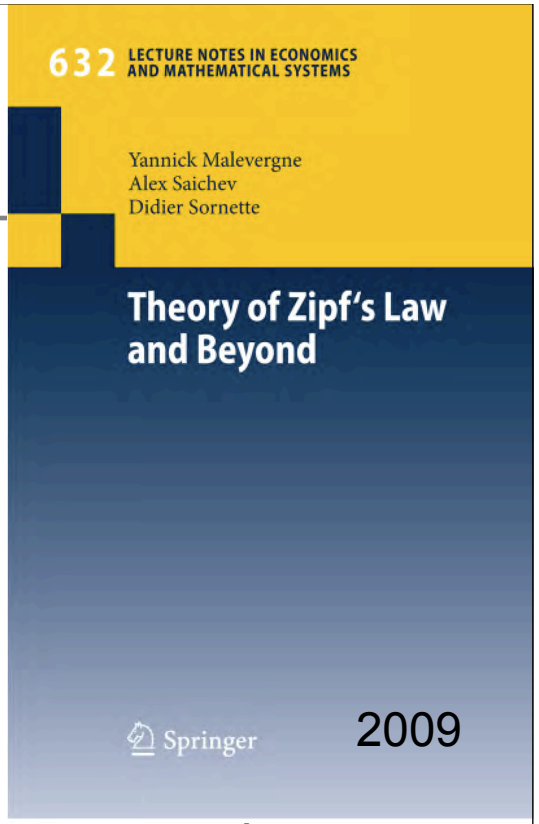


Fig. 7. French agglomerations: stretched exponential and "King effect".



Jean Laherrere and Didier Sornette, Stretched exponential distributions in Nature and Economy: ``Fat tails" with characteristic scales, European Physical Journal B 2, 525-539 (1998)

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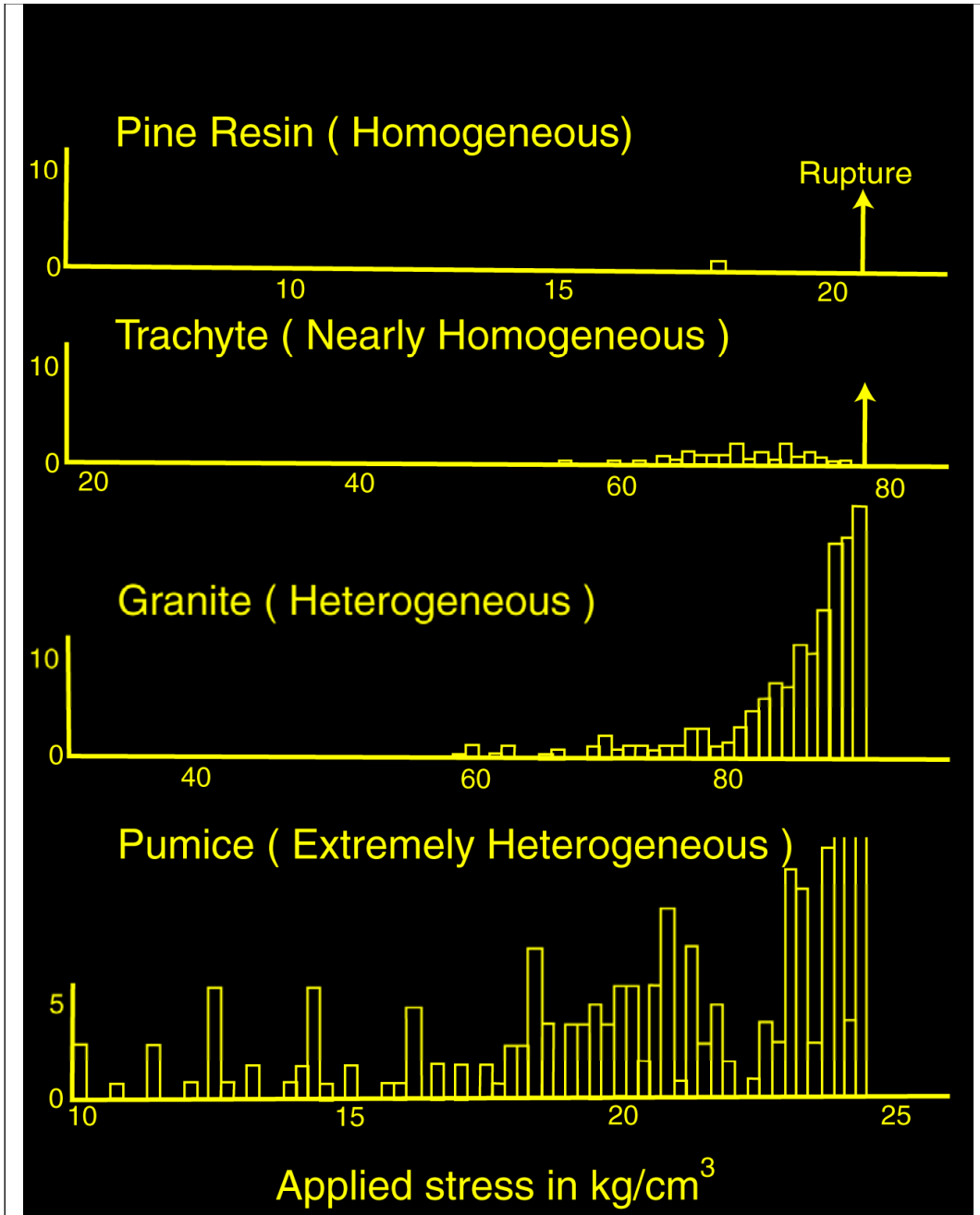
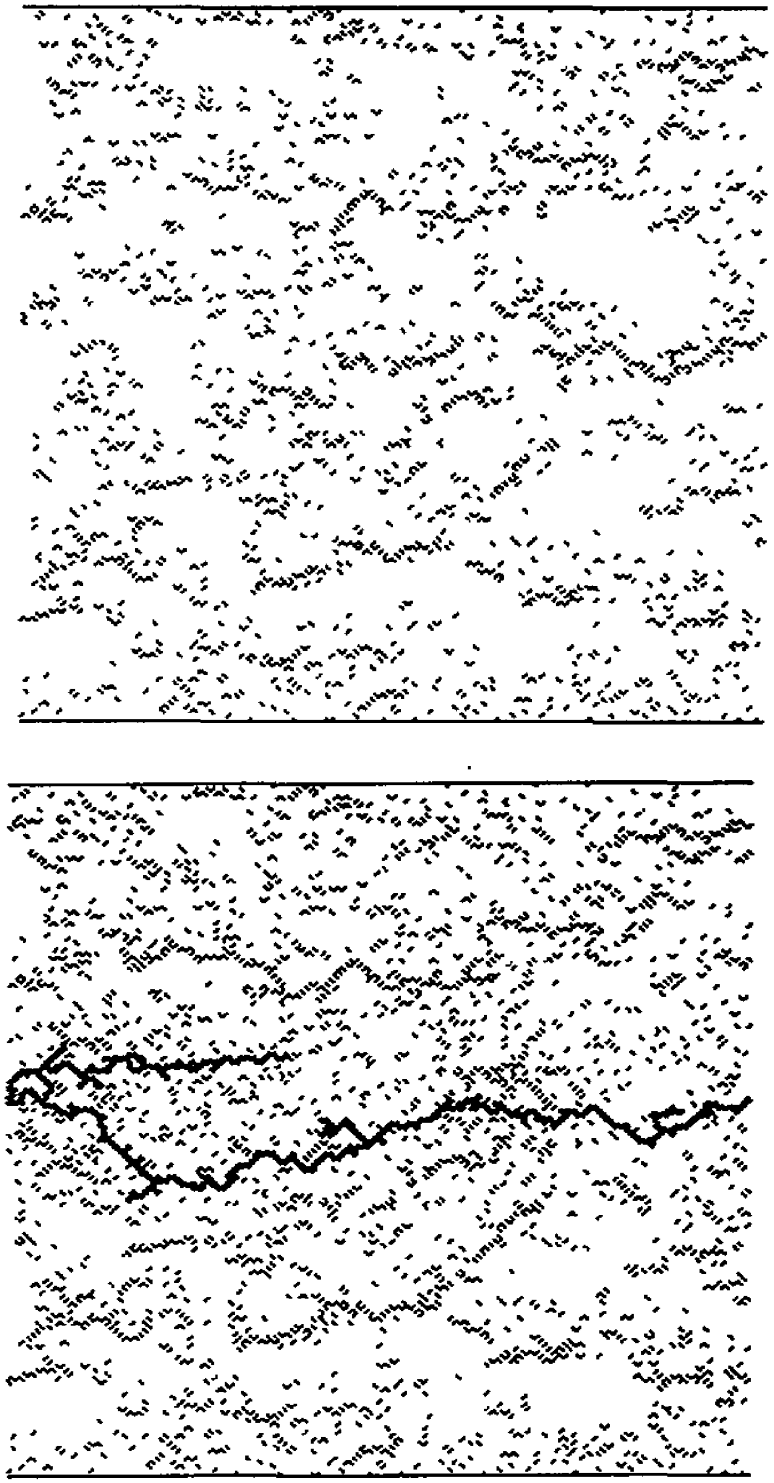
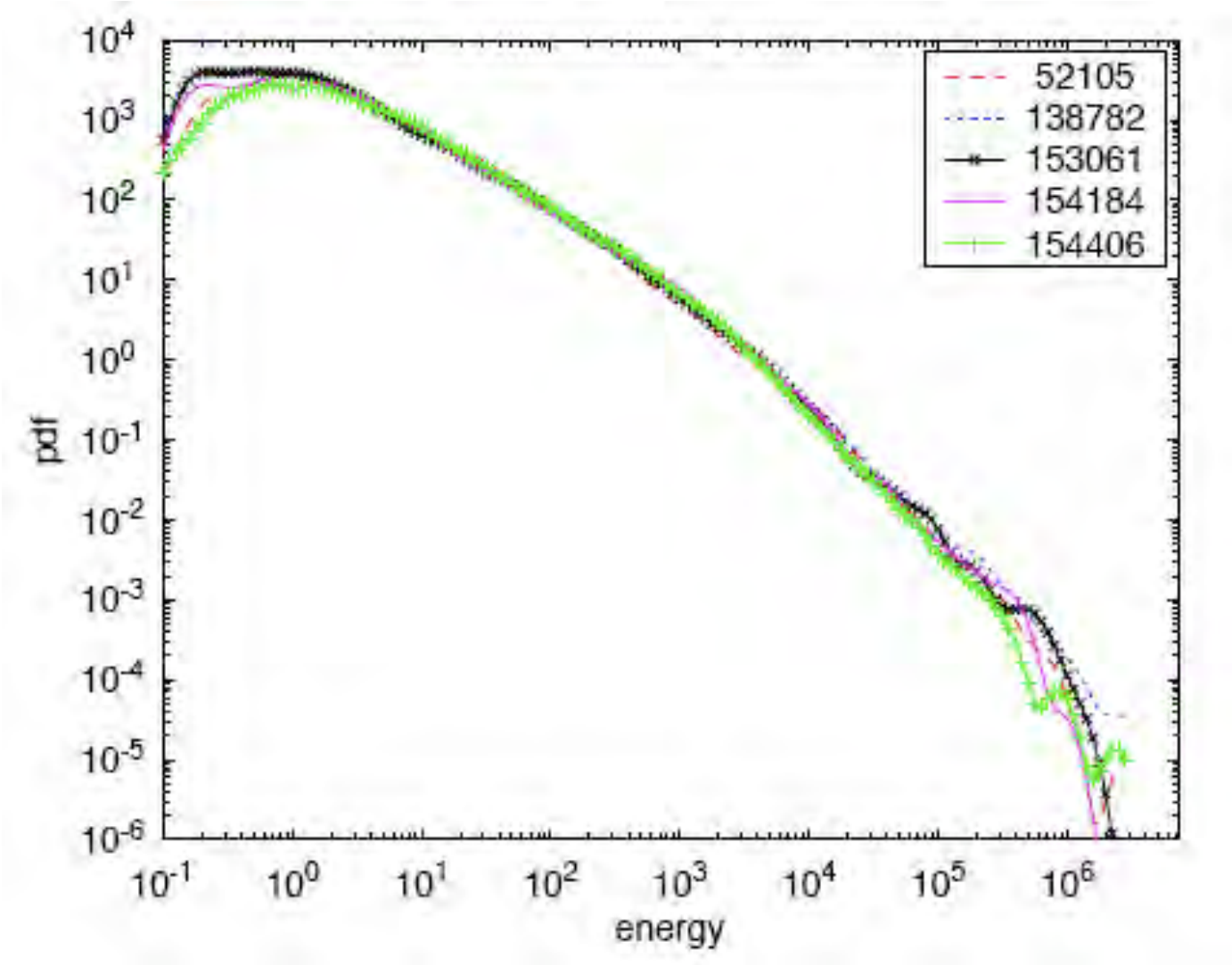


Fig. 4. Frequency of elastic shocks under increasing stresses in materials with different heterogeneity. From Mogi [1962]





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Energy distribution for the [+-62] specimen #4 at different times, for 5 time windows with 3400 events each. The average time (in seconds) of events in each window is given in the caption.

H. Nechad, A. Helmstetter, R. El Guerjouma and D. Sornette, Andrade and Critical Time-to-Failure Laws in Fiber-Matrix Composites: Experiments and Model, Journal of Mechanics and Physics of Solids (JMPS) 53, 1099-1127 (2005)

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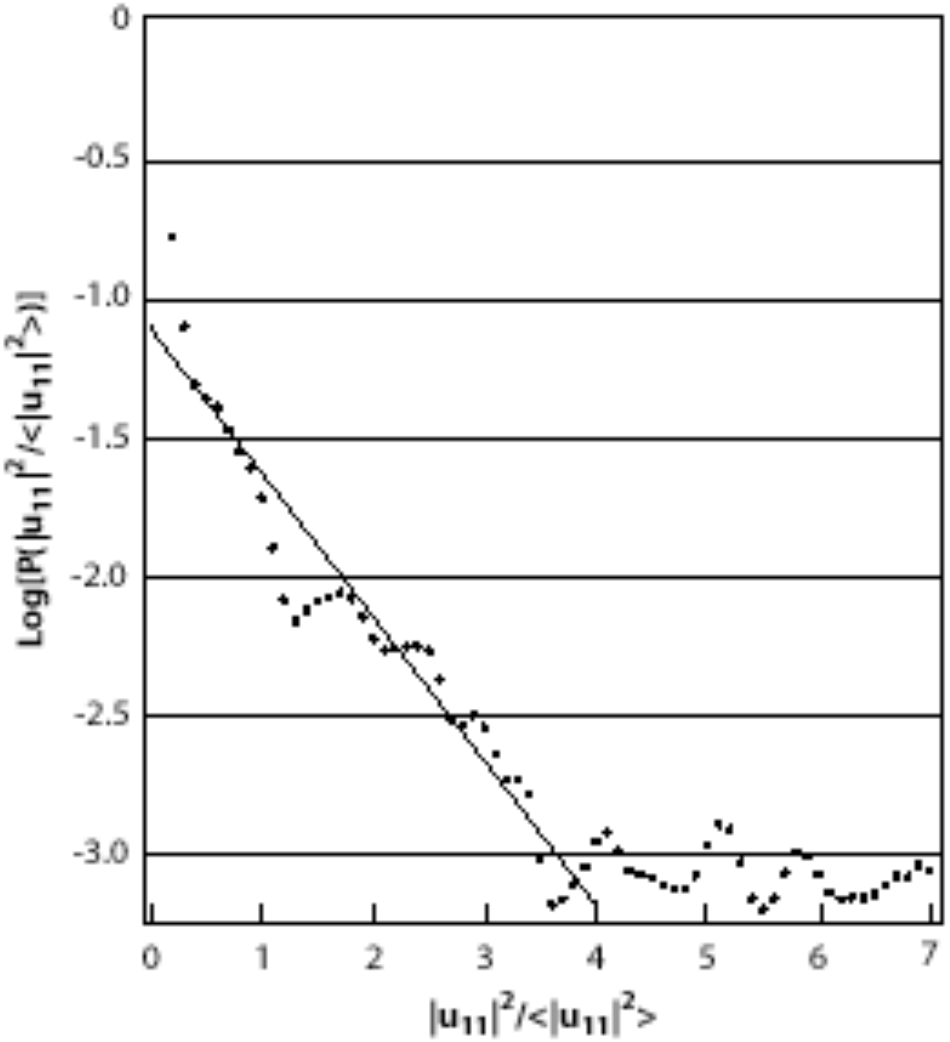
Mathematical Geophysics Conference

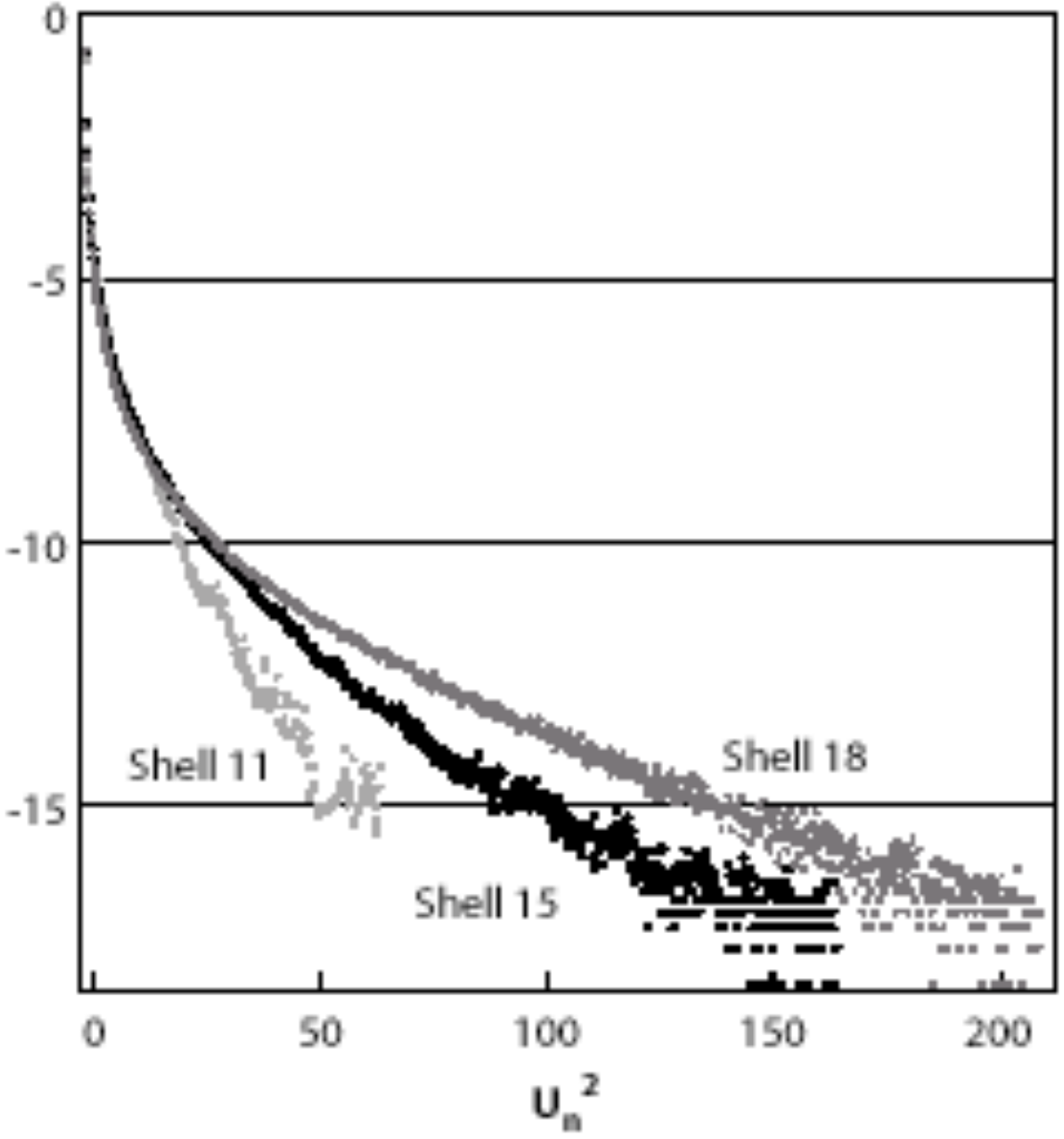
Extreme Earth Events

Villefranche-sur-Mer, 18-23 June 2000



L'vov, V.S., Pomyalov, A. and Procaccia, I. (2001) Outliers, Extreme Events and Multiscaling, Physical Review E 6305 (5), 6118, U158-U166.

FIG. 3.2. Apparent probability distribution function of the square of the fluid velocity, normalized to its time average, in the eleventh shell of the toy model of hydrodynamic turbulence discussed in the text. The vertical axis is in logarithmic scale such that the straight line, which helps the eye, qualifies as an apparent exponential distribution. Note the appearance of extremely sparse and large bursts of velocities at the extreme right above the extrapolation of the straight line. Reproduced from [252].



Pdf of the square of the Velocity as in the previous figure but for a much longer time series, so that the tail of the distributions for large Fluctuations is much better constrained. The hypothesis that there are no outliers is tested here by collapsing the distributions for the three shown layers. While this is a success for small fluctuations, the tails of the distributions for large events are very different, indicating that extreme fluctuations belong to a different class of their own and hence are outliers.

L'vov, V.S., Pomyalov, A. and Procaccia, I. (2001) Outliers, Extreme Events and Multiscaling, Physical Review E 6305 (5), 6118, U158-U166.

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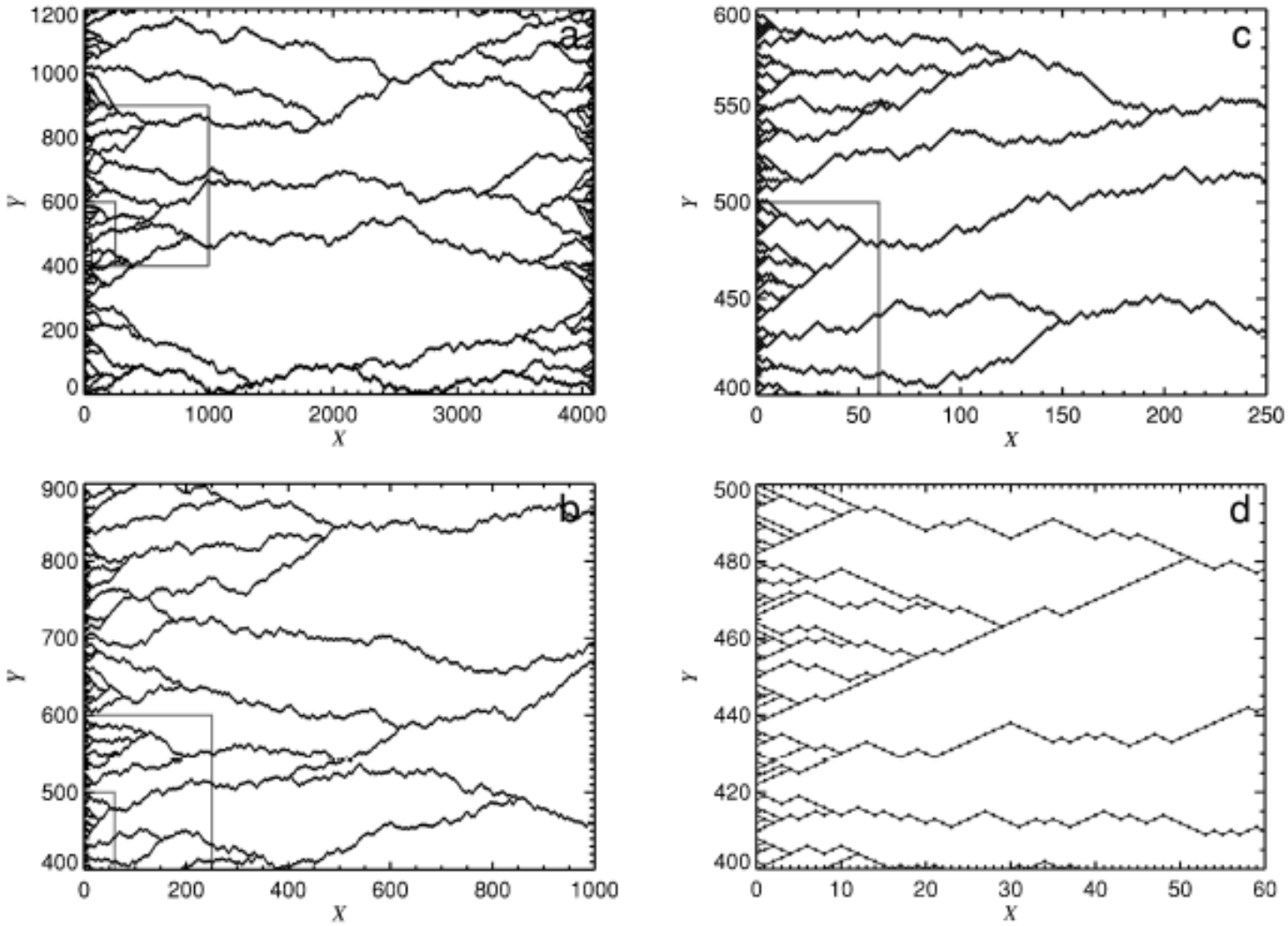
Metastable states in random media

Self-organized critical random directed polymers



P. Jogi and D. Sornette, Self-organized critical random directed polymers, Phys. Rev. E 57, 6931-6943 (1998)

FIG. 1. Typical set of optimal configurations for a RDP of length $W=4096$ and for $0 \leqslant y \leqslant 1200$: (a) global system [gray framed boxes outline regions of succeeding plots such that the horizontal and vertical extensions of these boxes follow Eqs. (10) and (8) with $\alpha \approx 0.9$], (b) magnification of the largest box in (a), (c) magnification of the largest box in (b) and (d) magnification of the box in (c). Note, that at each grid point of the lattice we assign an independent random number drawn from an exponential distribution with unit mean and variance.

Definition of “avalanches”

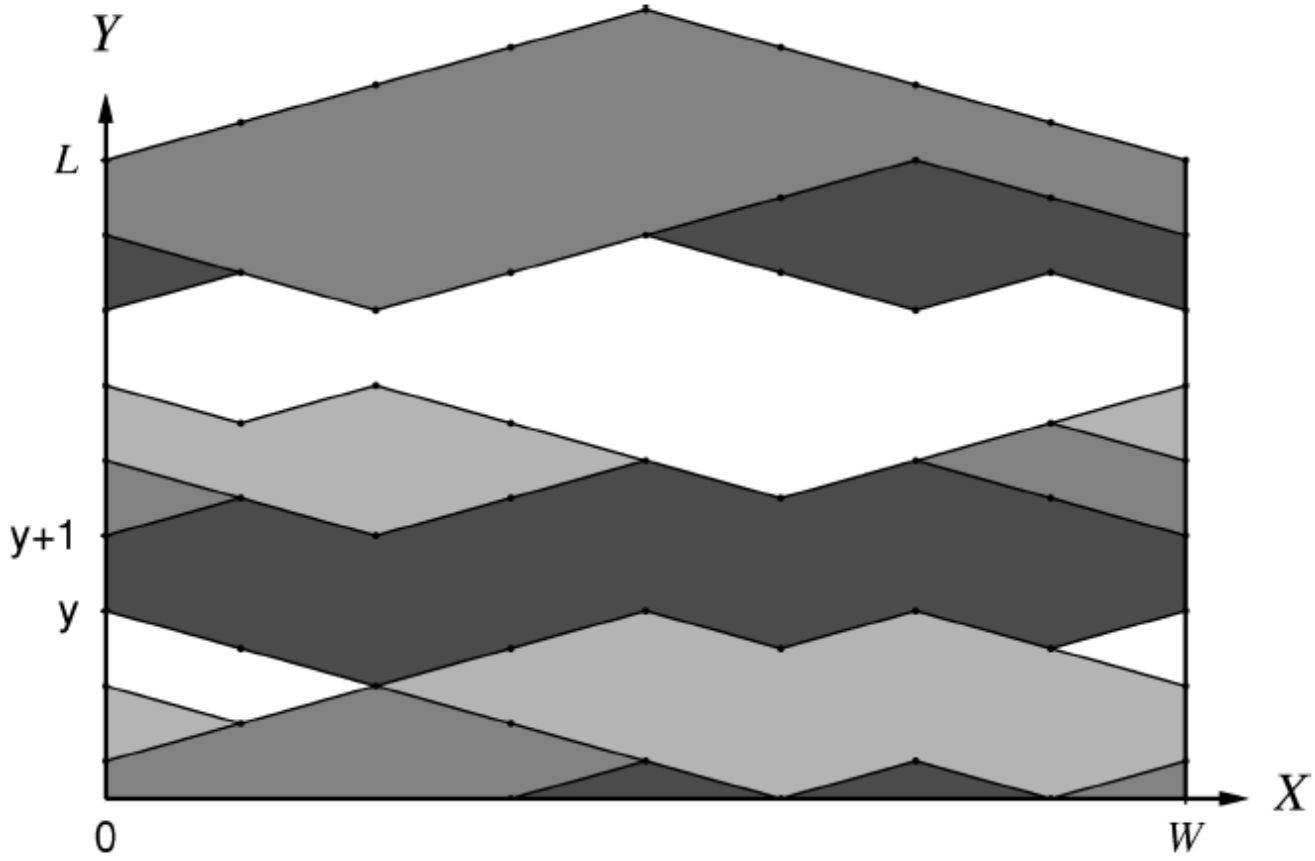


FIG. 2. Schematic representation of optimal RDPs fixed at their two end points. An avalanche is defined by the area S spanned by the transition from the optimal configuration at y to $y+1$, i.e., S is the area interior to the perimeter formed by the union of the two optimal RDP configurations at y and $y+1$ and the two vertical segments $((0,y);(0,y+1))$ and $((W,y);(W,y+1))$. The successive avalanches are represented in different gray scales.

$$P(S)dS \propto \frac{W^{2/3}}{S^{1+\mu}} dS,$$

+ characteristic avalanche scale

$$\mu = 2/5.$$

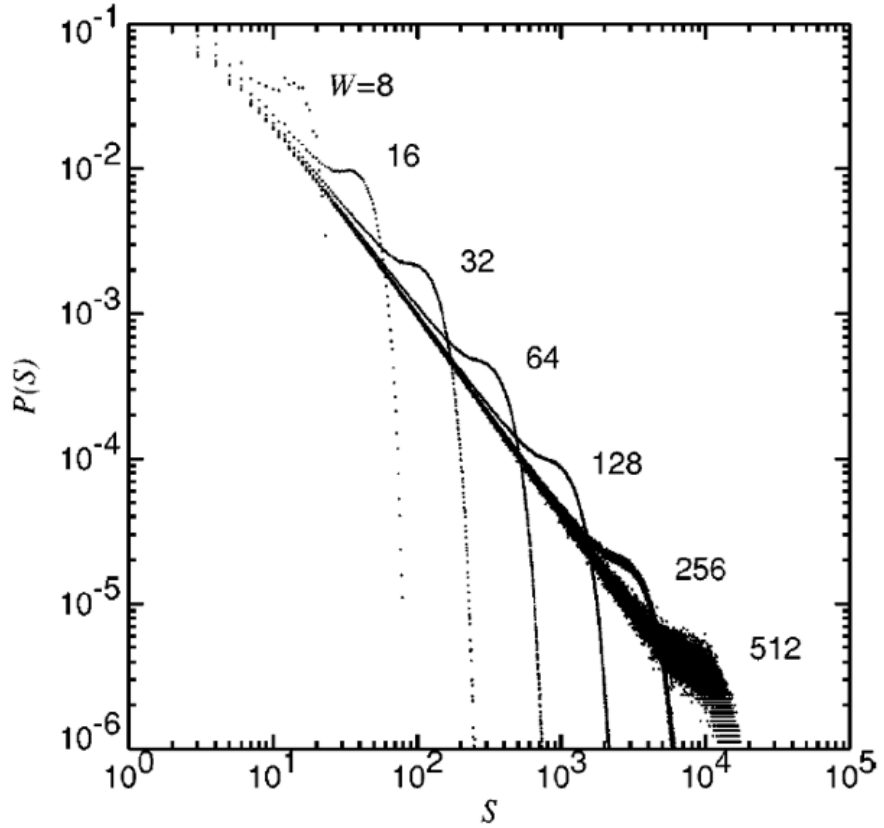


FIG. 3. Distribution $P(S)$ of RDP avalanche sizes obtained numerically for system widths from $W=8$ to 512 on a log-log plot. Here the system lengths L are 2×10^7 (for $W=8$), 3×10^6($W=16$), 2×10^7($W=32$), 10^8($W=64$), 2×10^8($W=128$),5×10^7($W=256$), and 9×10^6($W=512$).

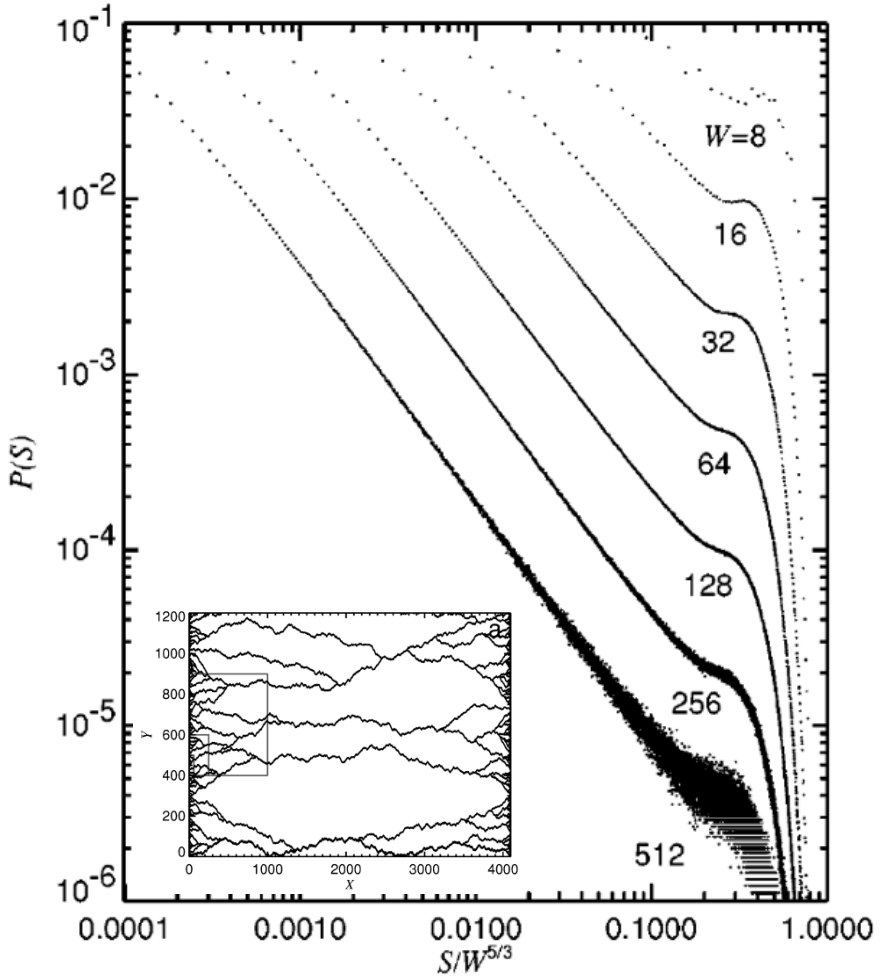
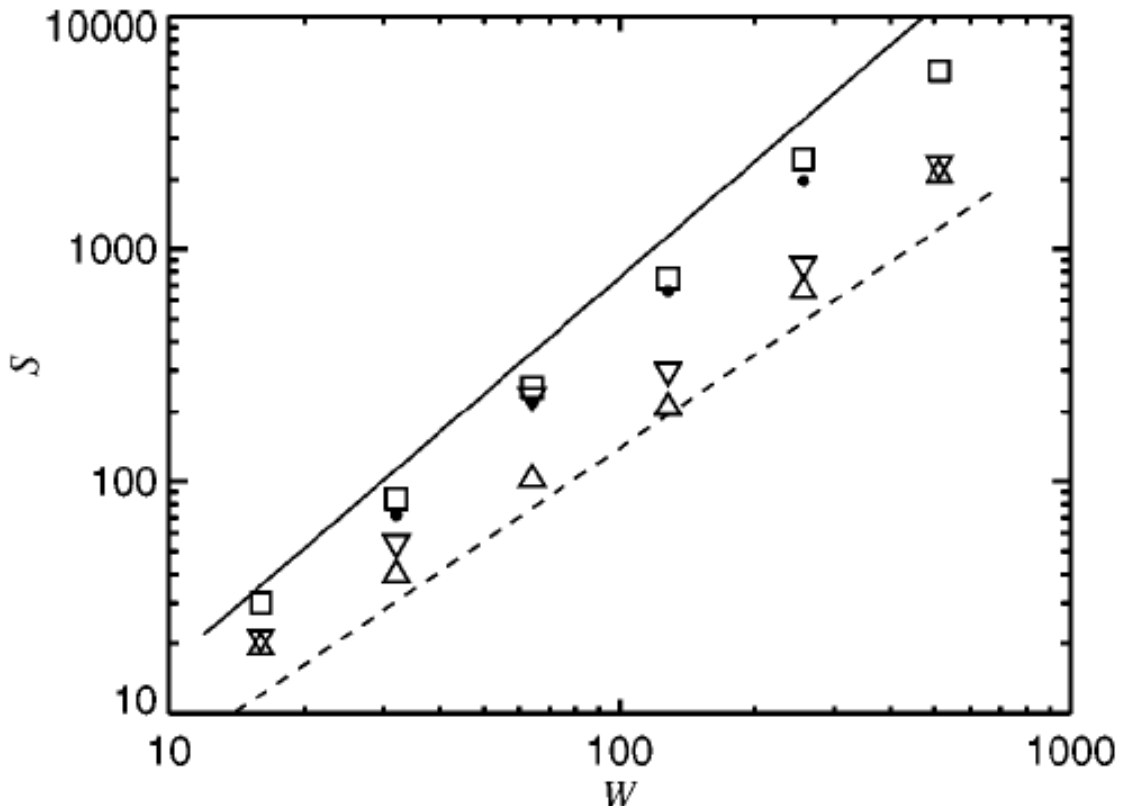


FIG. 4. $P(S)$ as a function of the rescaled variable $S/W^{5/3}$ for $W=8$–512 on a log-log plot.

Two characteristic scales and their scaling laws



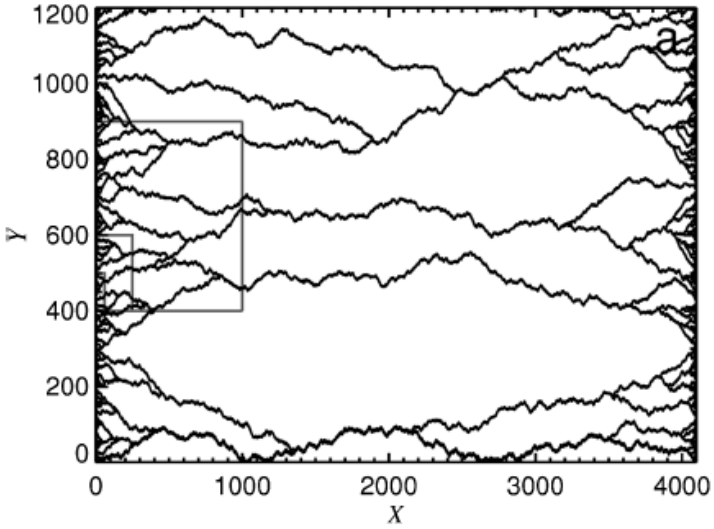


FIG. 7. Estimated W dependence of the three characteristic avalanche sizes. S_{up}, the upper limit for which $P(S)$ seems well approximated by a power law, is judged from Fig. 4 to have high and low values marked by ∇ and $\triangle$, respectively (values taken at the midpoint of the triangle's horizontal side). S_{bump} ($\square$) tracks the location of the bump of $P(S)$ and is here chosen as the position of the inflection point of the different distributions displayed in Fig. 3. S_{tail}, ($\bullet$) represents the lower limit of the linear domain of the curves in Fig. 6. The solid line (proportional to $W^{5/3}$) and the dashed line (proportional to $W^{4/3}$) are included as guides.

P. Jogi and D. Sornette,
Self-organized critical
random directed polymers,
Phys. Rev. E 57,
6931-6943 (1998)

Beyond power laws: 7 examples of "Dragons"

Financial economics: Outliers and dragons in the distribution of financial drawdowns.

Population geography: Paris as the dragon-king in the Zipf distribution of French city sizes.

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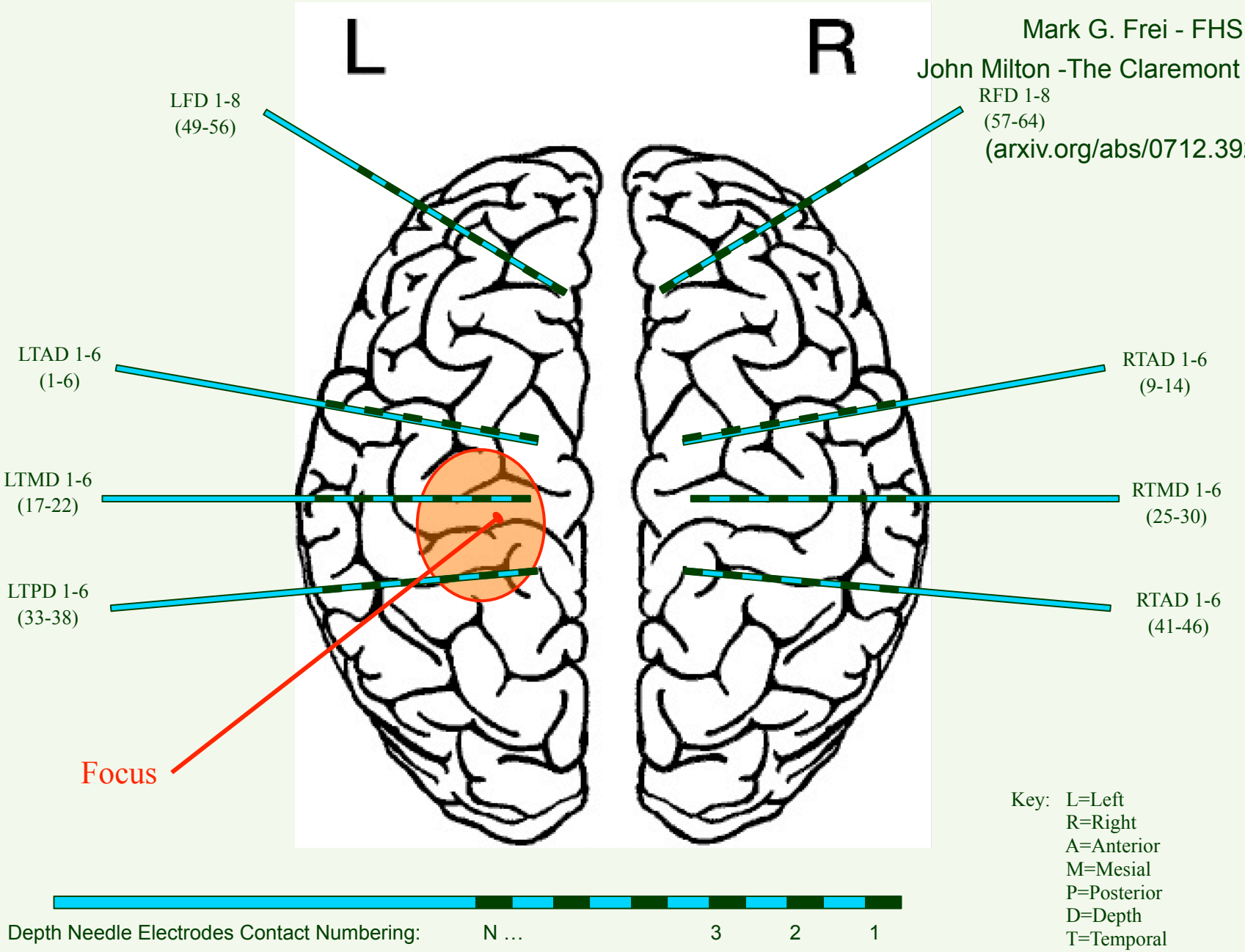
Metastable states in random media: Self-organized critical random directed polymers

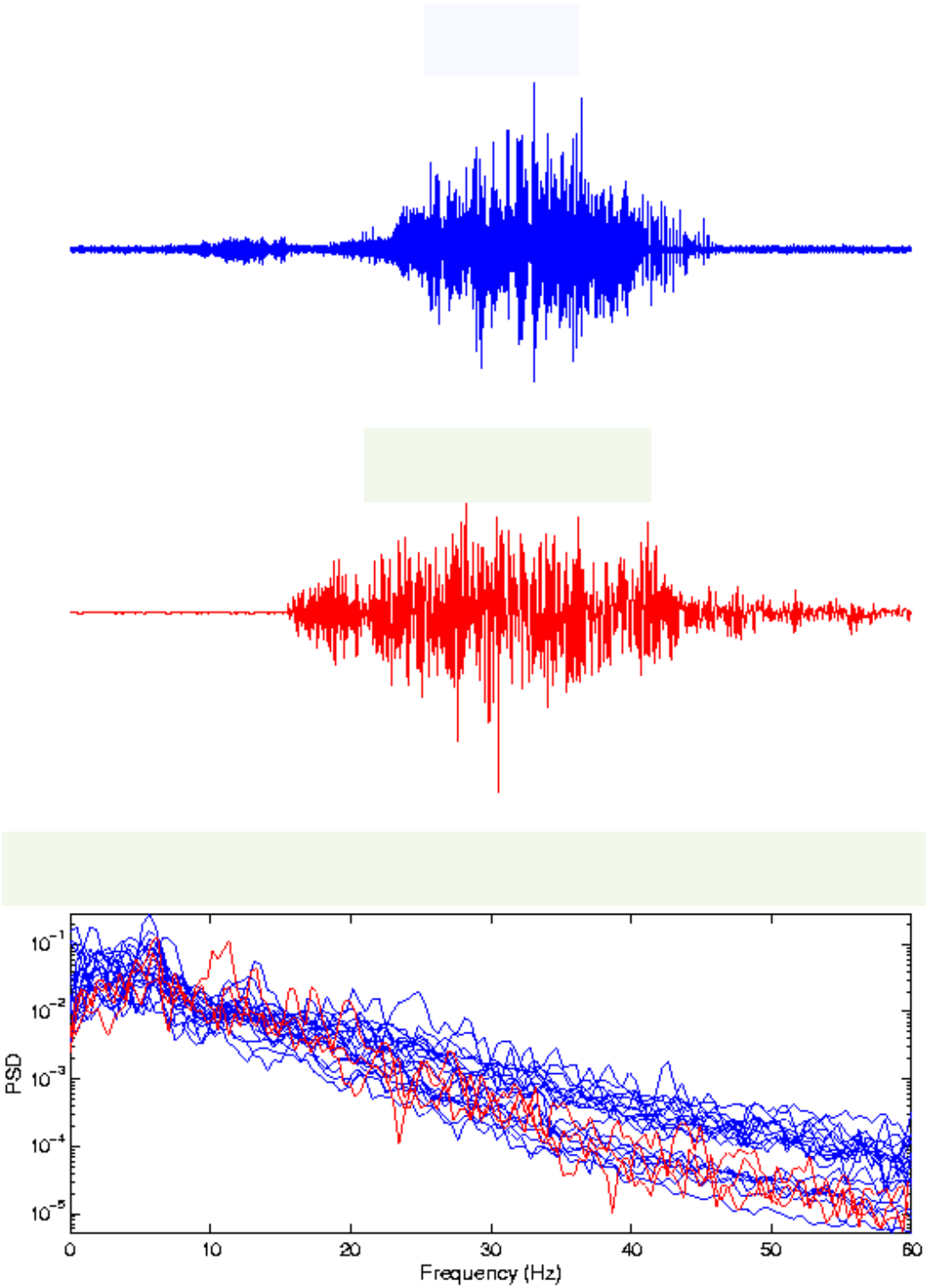
Brain medicine: Epileptic seizures

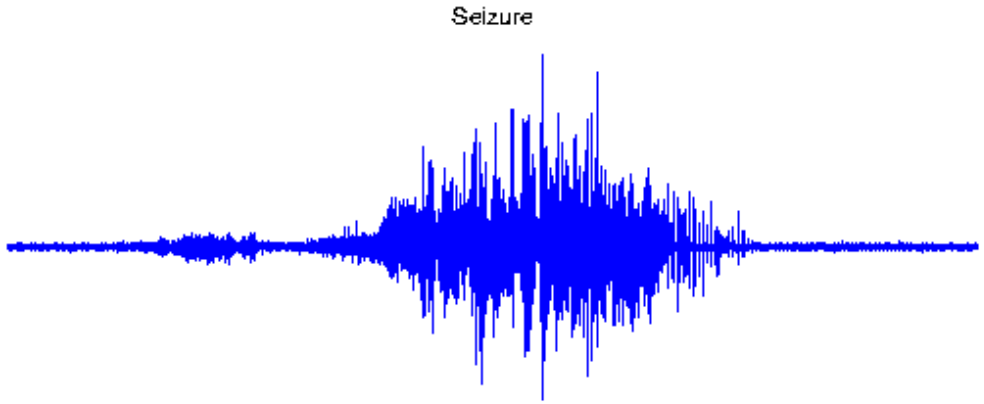
Geophysics: Gutenberg-Richter law and characteristic earthquakes.

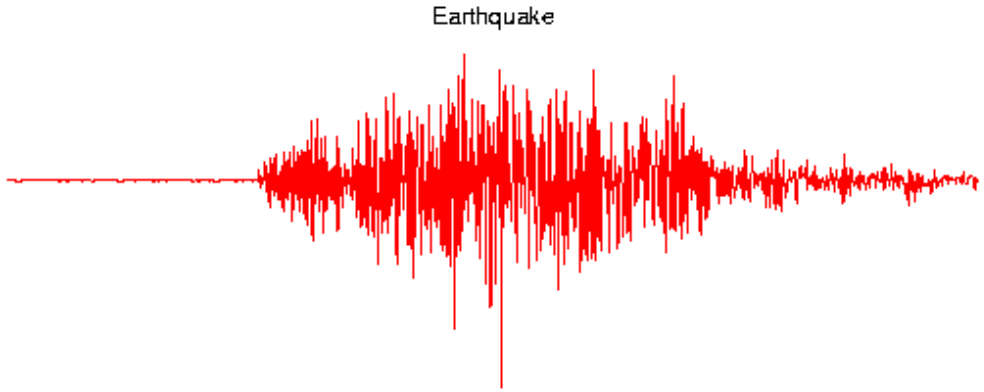
Epileptic Seizures – Quakes of the Brain?

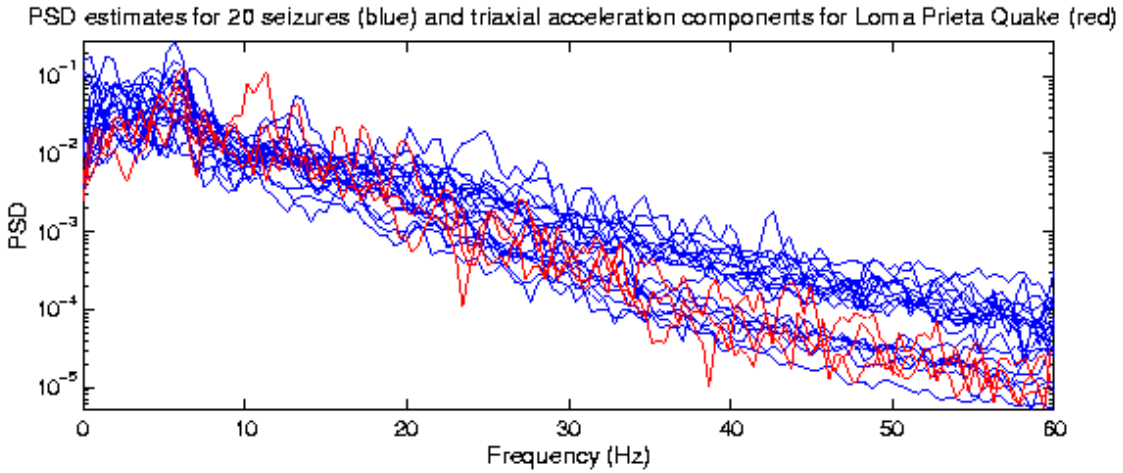
with Ivan Osorio – KUMC & FHS
Mark G. Frei - FHS
John Milton -The Claremont Colleges



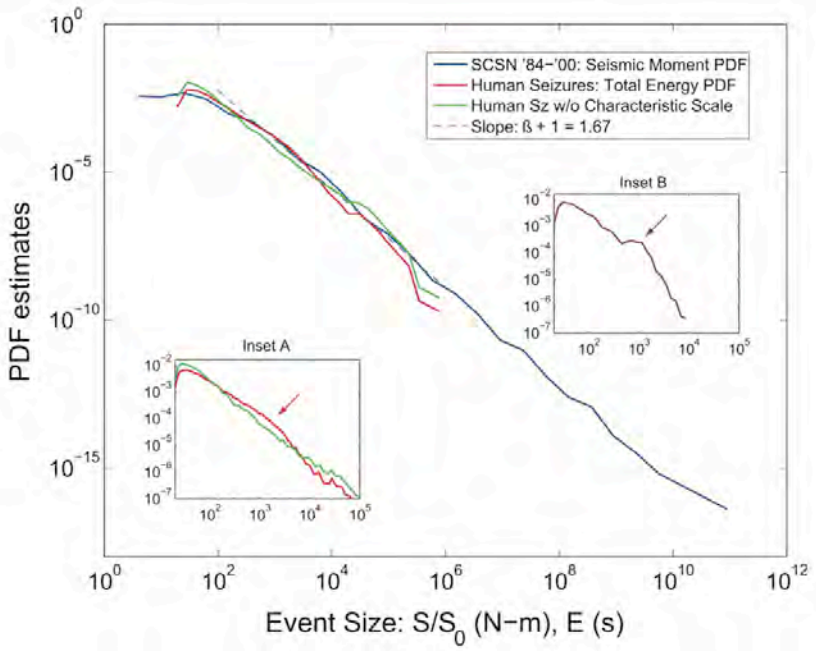

PSD
Frequency (Hz)
0
10
20
30
40
50
60


Seizure

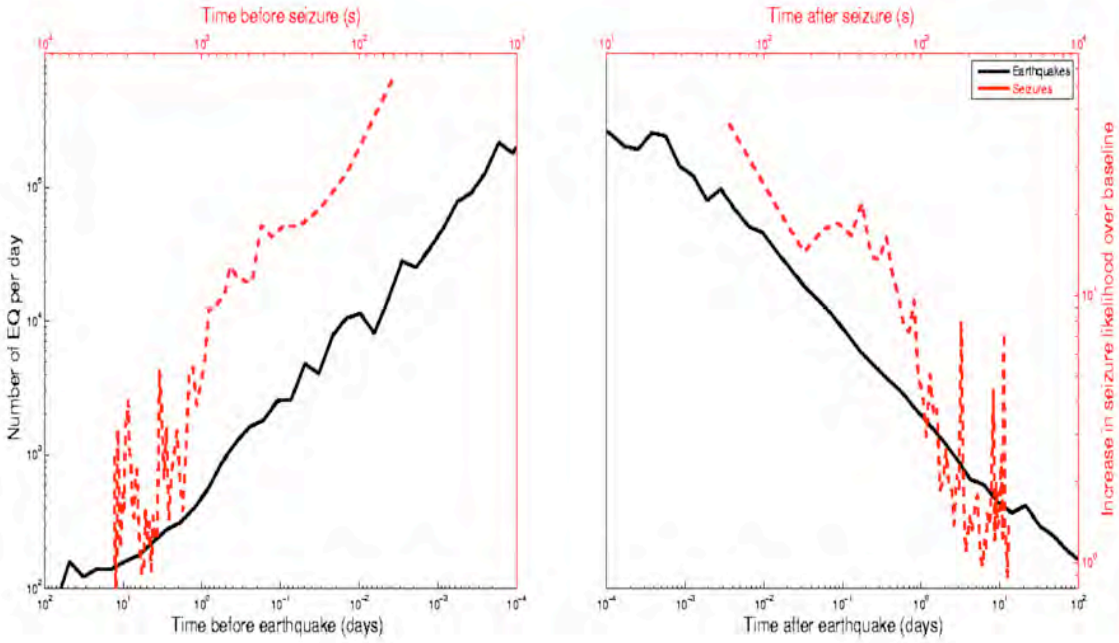

Earthquake


PSD estimates for 20 seizures (blue) and triaxial acceleration components for Loma Prieta Quake (red)
PSD
Frequency (Hz)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
10
20
30
40
50
60

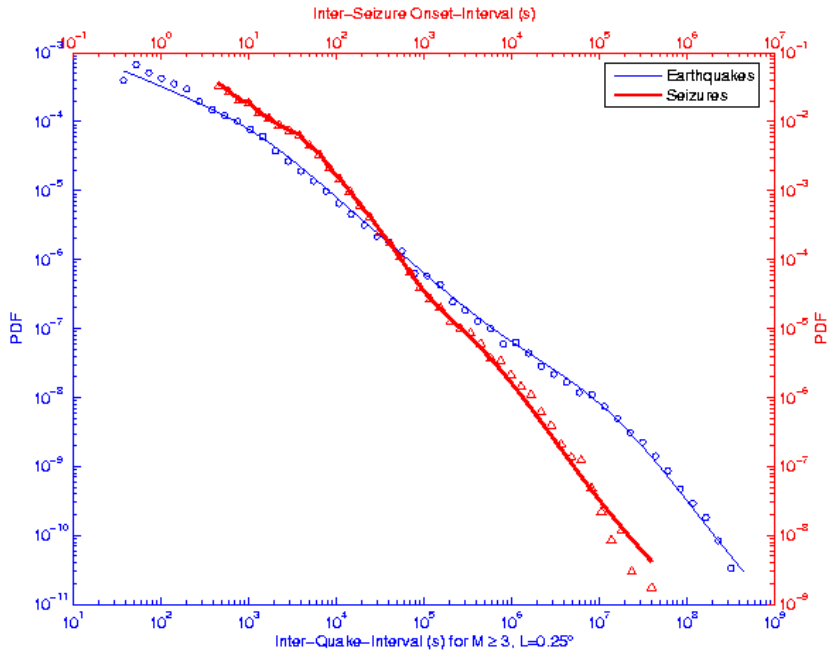
Gutenberg-Richter distribution of sizes



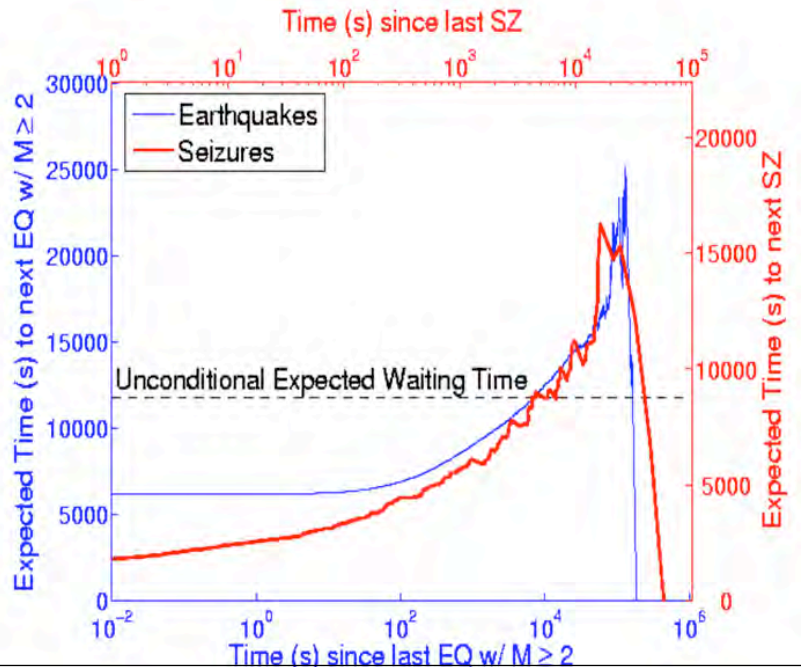
Omori law: Direct and Inverse



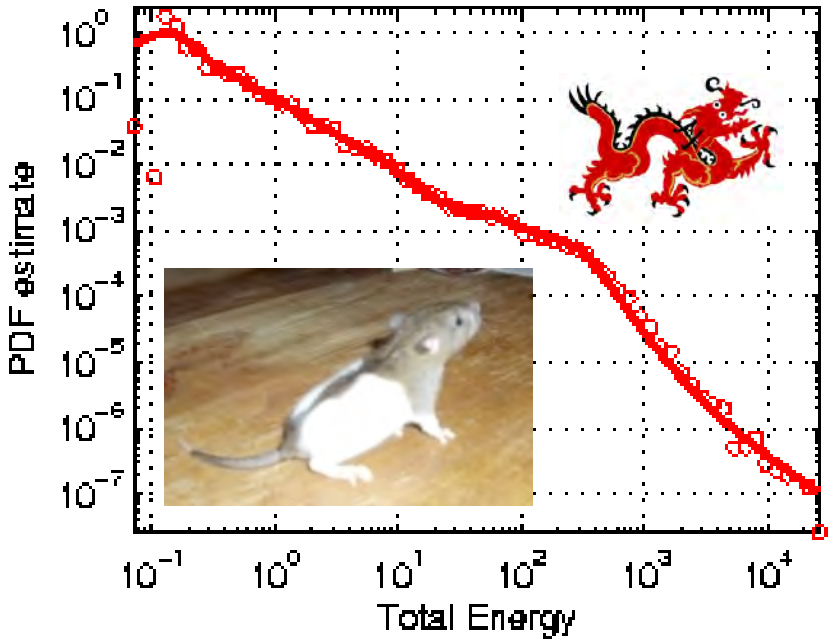
pdf of inter-event waiting times

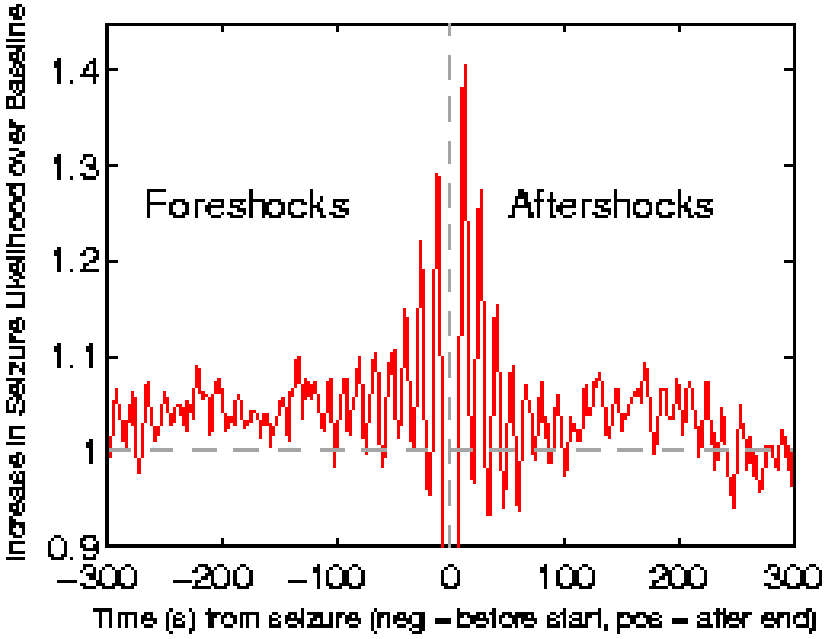


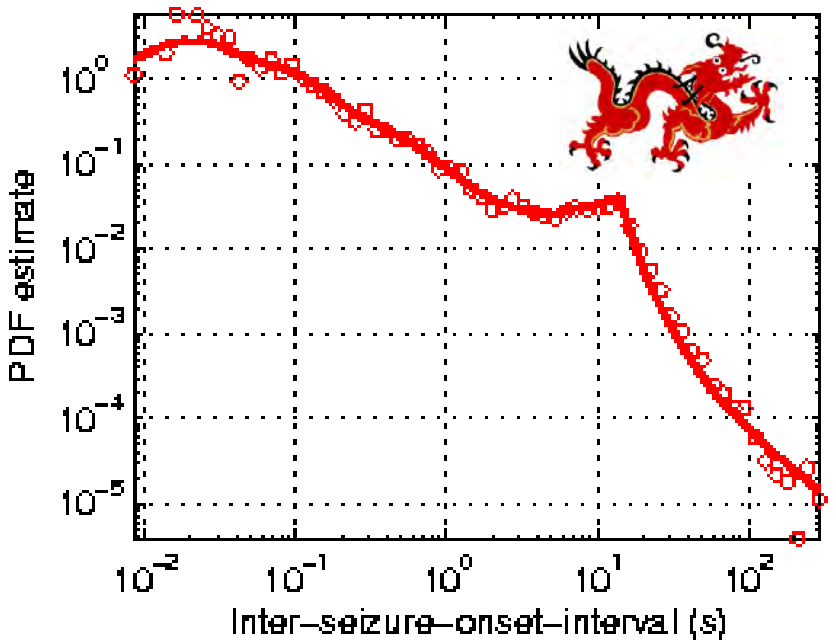
The longer it has been since the last event, the longer it will be since the next one!

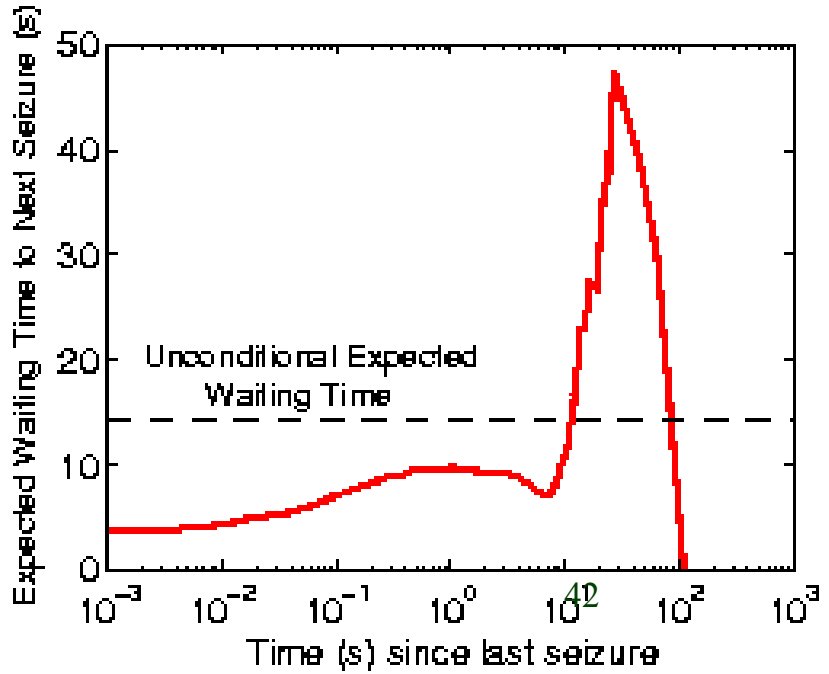


19 rats treated intravenously (2) with the convulsant 3-mercapto-proprionic acid (3-MPA)





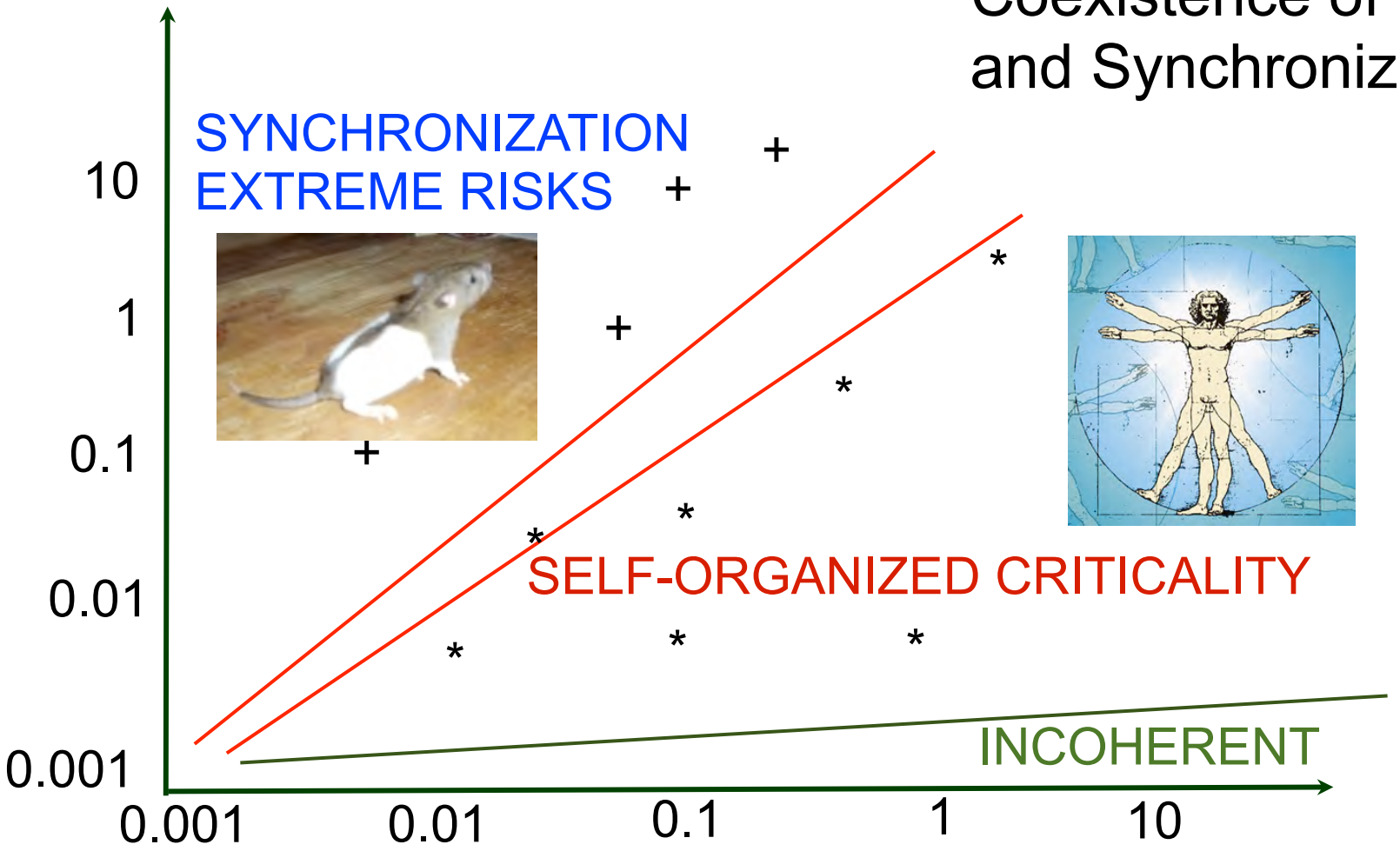




Generic diagram for coupled threshold oscillators of relaxation

Interaction (coupling) strength

Coexistence of SOC and Synchronized behavior



Heterogeneity; level of compartmentalization

Landau-Ginzburg Theory of Self-Organized Criticality
and of Dragon-kings!

Dynamics of an order parameter (OP) and of the corresponding *control* parameter (CP): within the sandpile picture, $\frac{\partial h}{\partial x}$ is the slope of the sandpile, h being the local height, and S is the state variable distinguishing between static grains ($S = 0$) and rolling grains ($S \neq 0$).

L. Gil and D. Sornette "Landau-Ginzburg theory of self-organized criticality", Phys. Rev.Lett. 76, 3991-3994 (1996)

Normal form of sub-critical bifurcation

$$\frac{\partial S}{\partial t} = \chi \left\{ \mu S + 2\beta S^3 - S^5 \right\} \qquad (1)$$

where

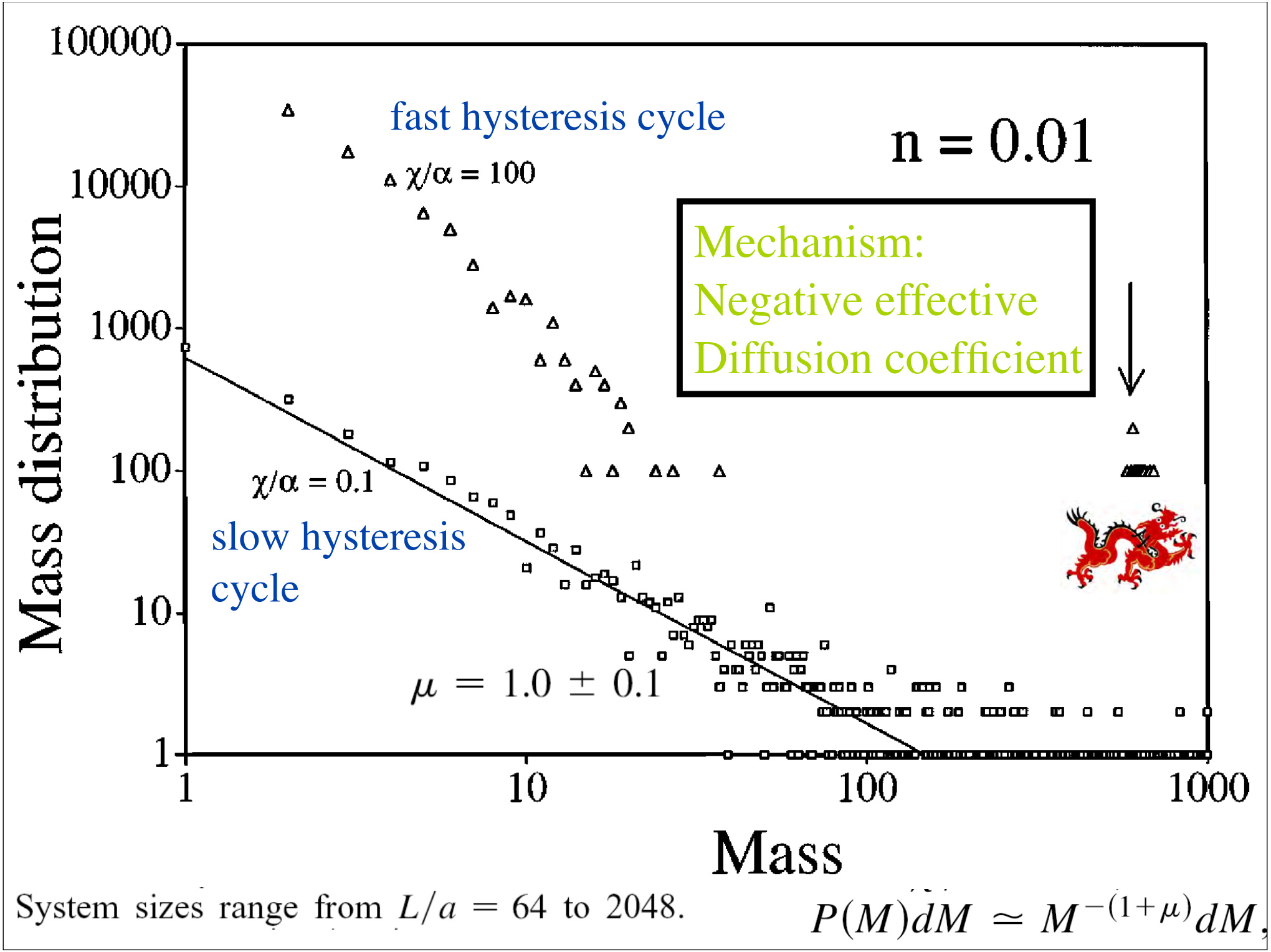
$$\mu = \left[\left(\frac{\partial h}{\partial x} \right)^2 - \left(\frac{\partial h}{\partial x}|_c \right)^2 \right] \qquad (2)$$

and $\beta > 0$ (subcritical condition).

$$F\left(S, \frac{\partial h}{\partial x}\right) = -\alpha \frac{\partial h}{\partial x} S^2, \qquad \alpha > 0$$

Diffusion equation

$$\frac{\partial h}{\partial t} = -\frac{\partial F\left(S, \frac{\partial h}{\partial x}\right)}{\partial x} + \Phi \qquad (3)$$



System sizes range from $L/a = 64$ to 2048.

$$P(M)dM \simeq M^{-(1+\mu)}dM,$$

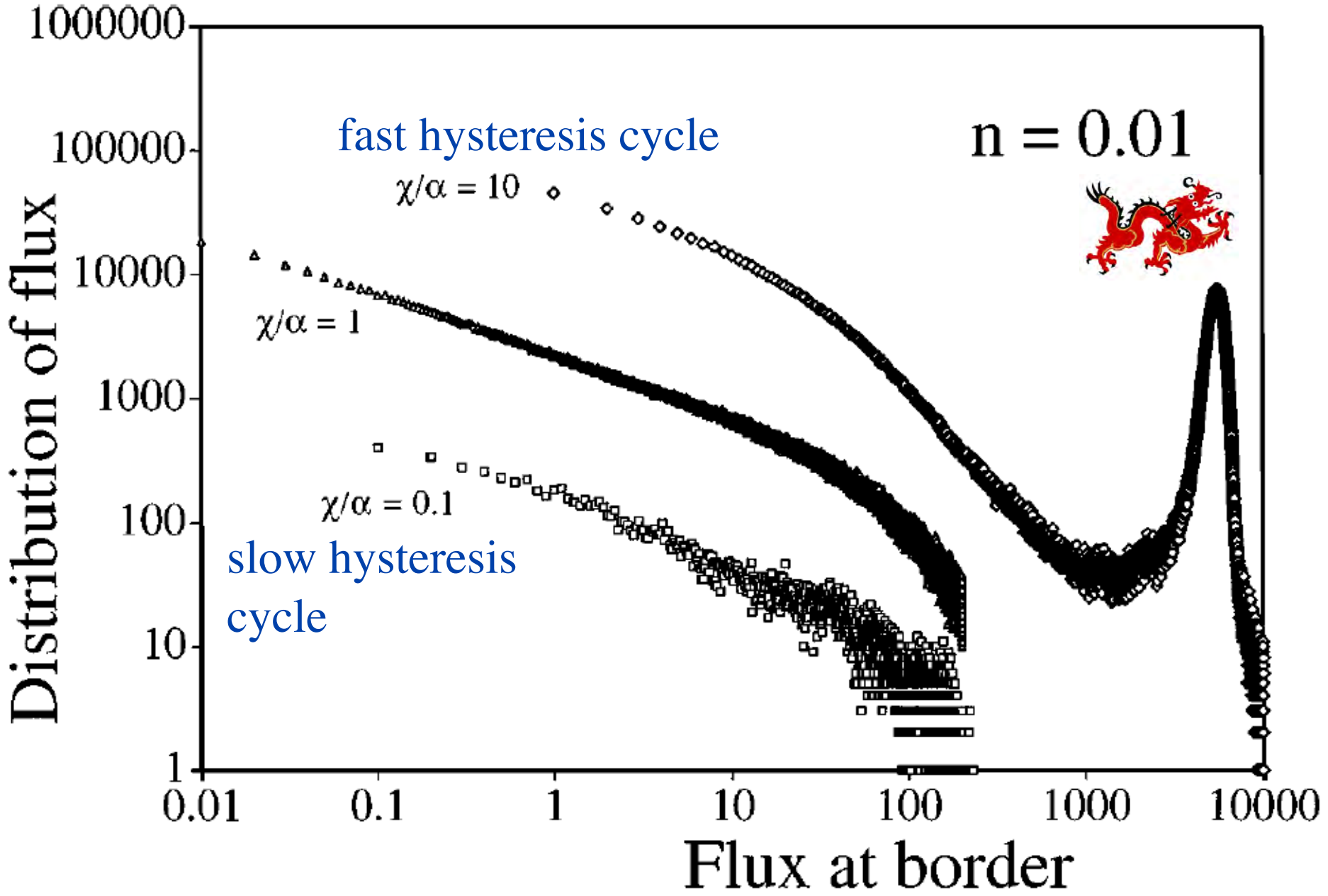


FIG. 3. Distribution $P(J)$ of flux amplitudes at the right border, in the same conditions as for Fig. 1.

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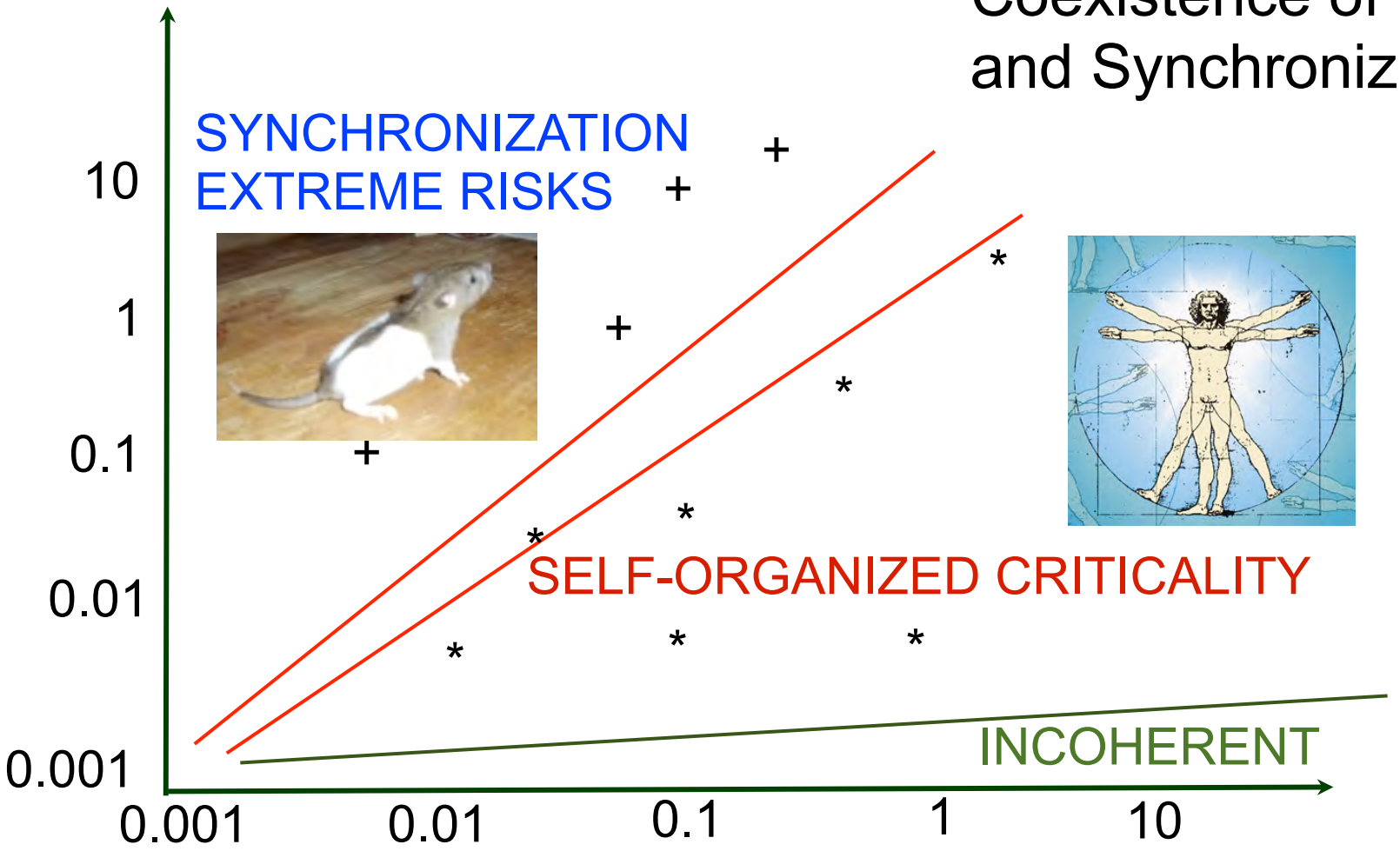
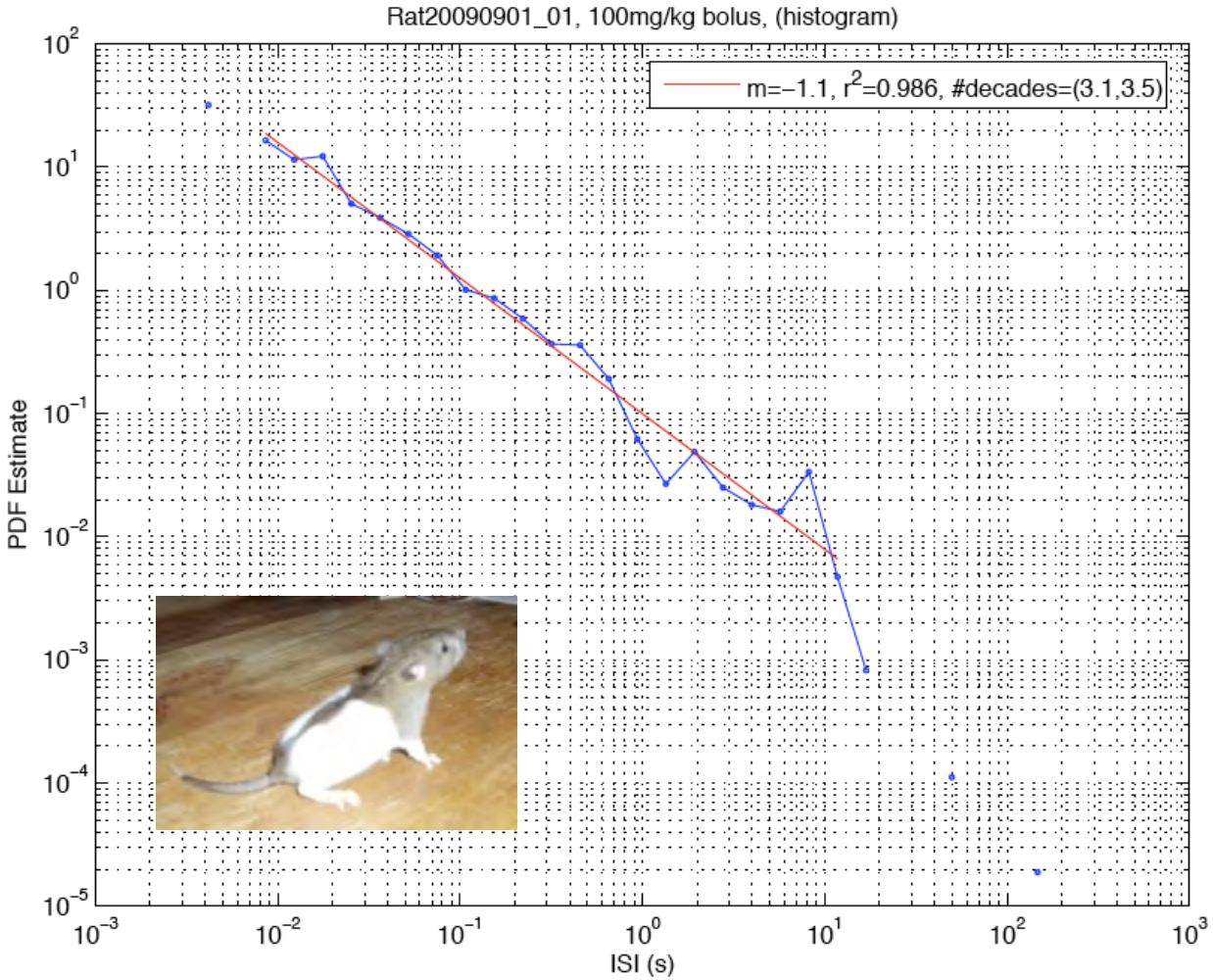


Heterogeneity; level of compartmentalization

Low dose of convulsant in rats (like most humans)

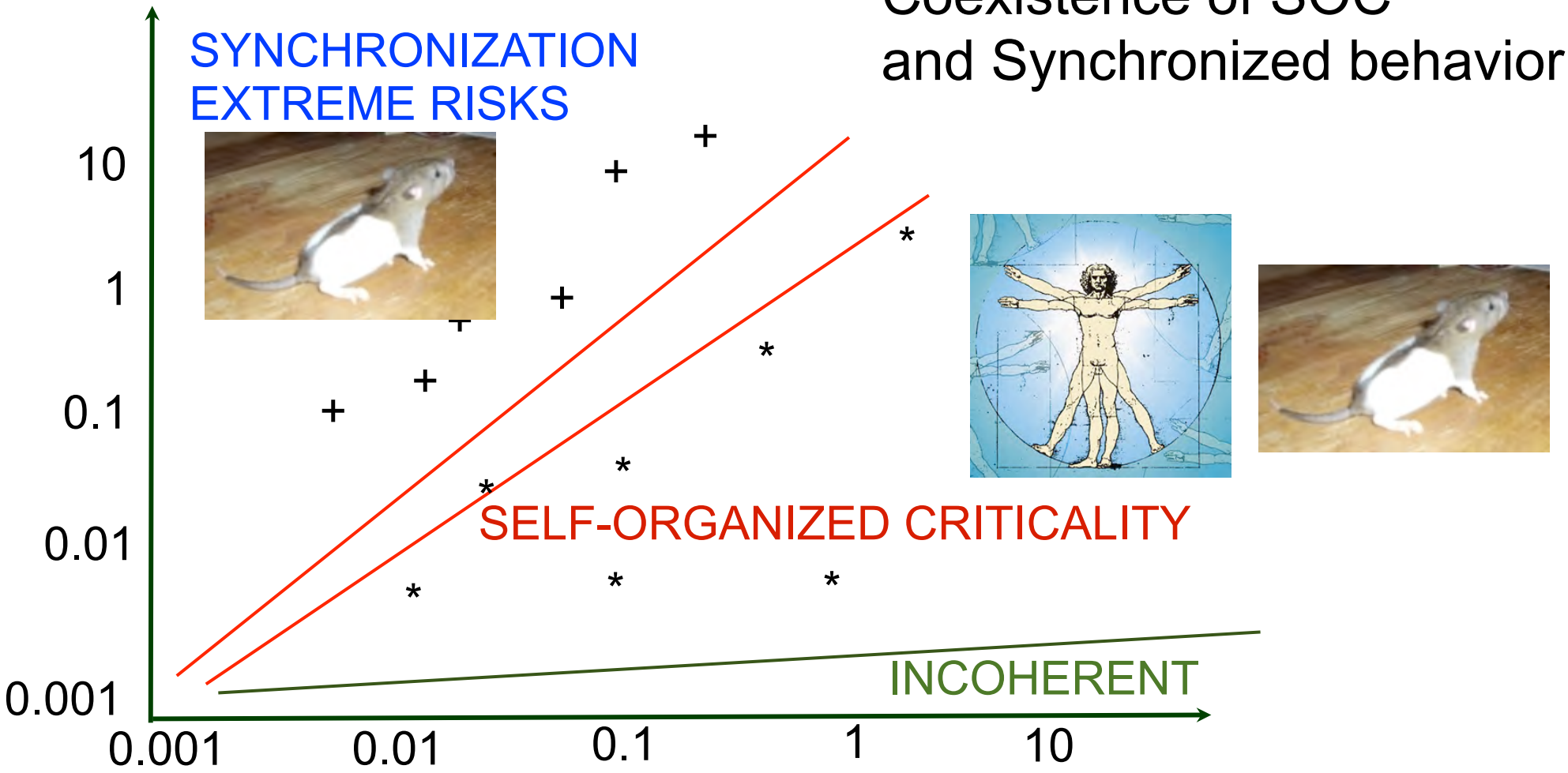


Distribution of inter-seizure time intervals for rat 5, demonstrating a pure power law, which is characteristic of the SOC state. This scale-free distribution should be contrasted with the pdf's obtained for the other rats, which are marked by a strong shoulder associated with a characteristic time scale, which reveals the periodic regime.

Generic diagram for coupled threshold oscillators of relaxation

Interaction (coupling) strength

Coexistence of SOC and Synchronized behavior

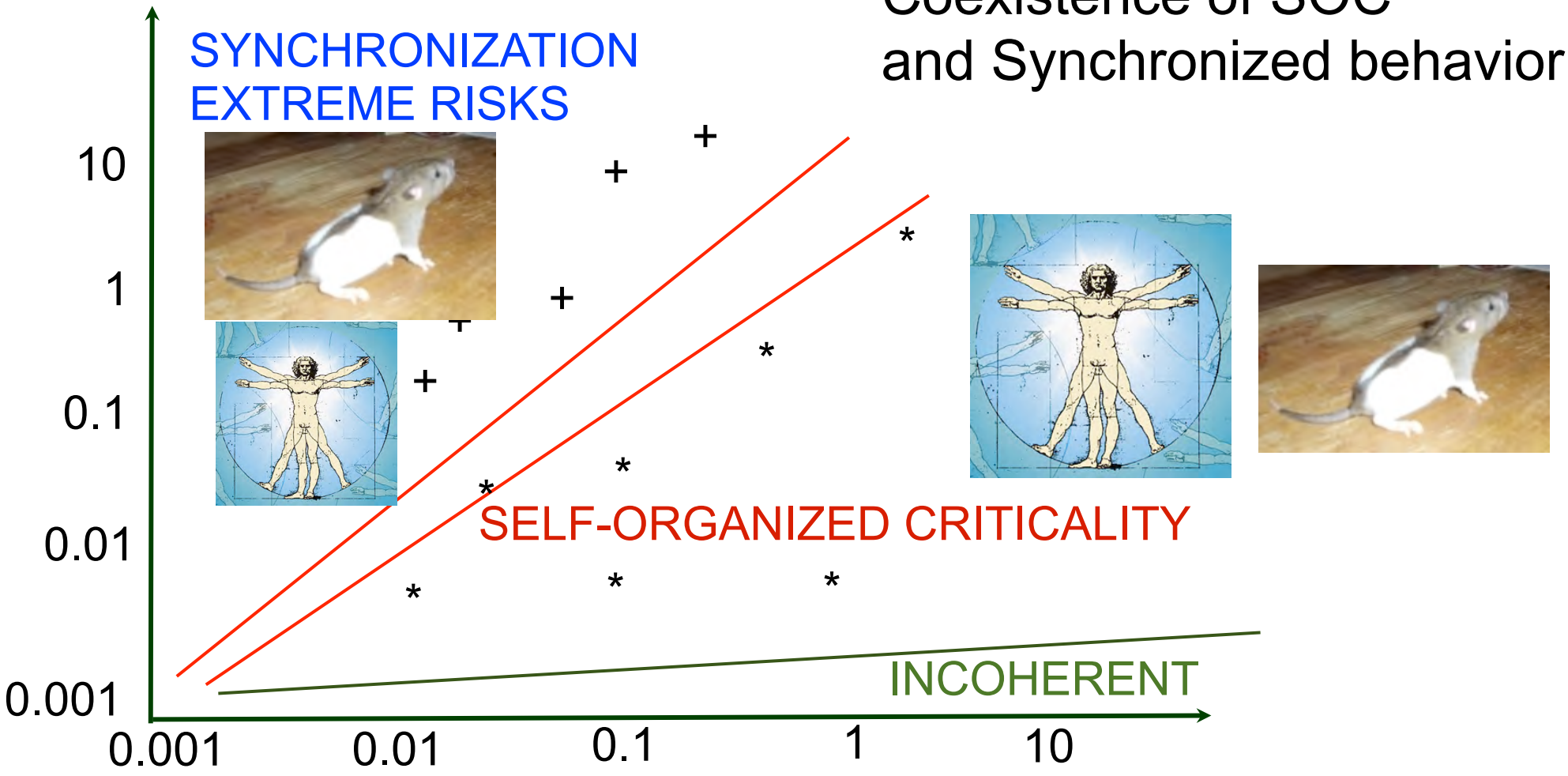


Heterogeneity; level of compartmentalization

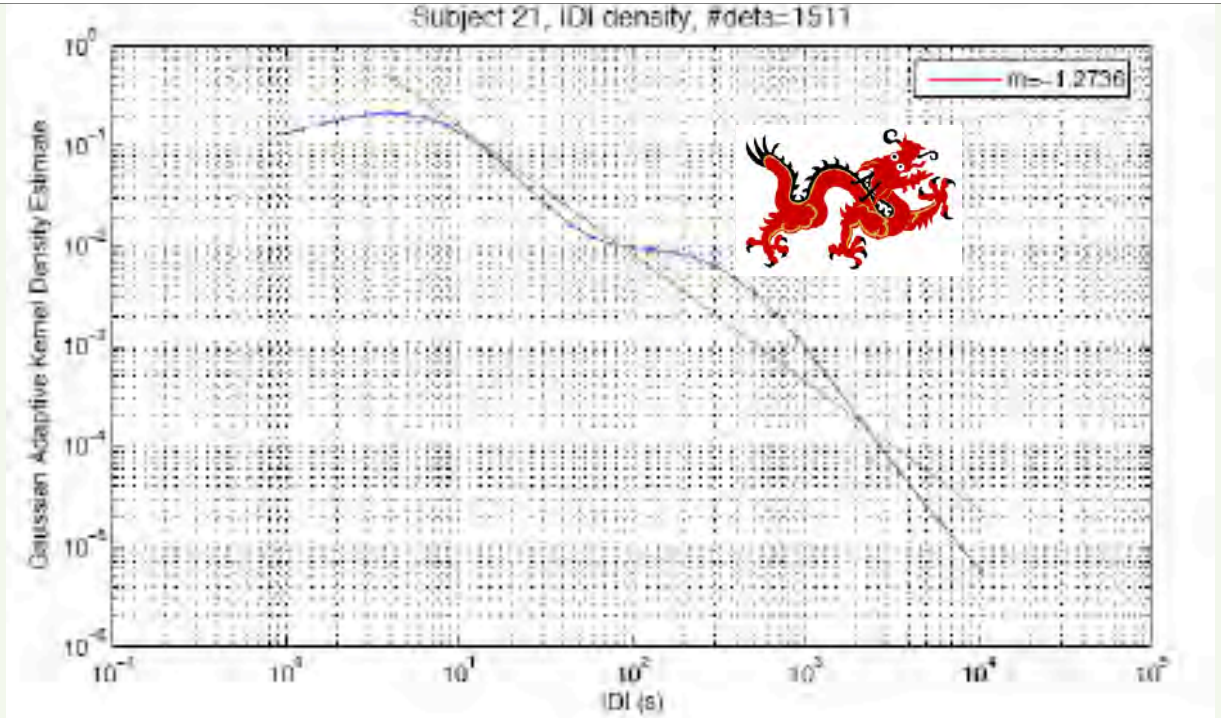
Generic diagram for coupled threshold oscillators of relaxation

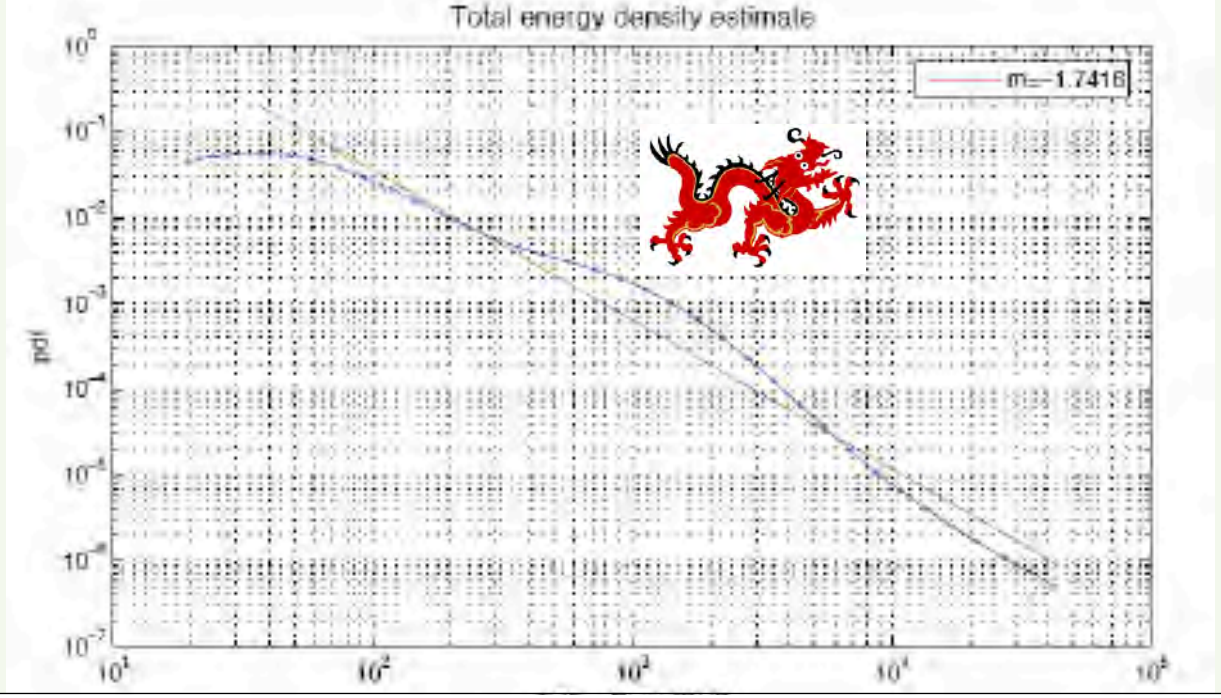
Interaction (coupling) strength

Coexistence of SOC and Synchronized behavior



Heterogeneity; level of compartmentalization





Some humans are like rats with large doses of convulsant

The pdf's of the seizure energies and of the inter-seizure waiting times for subject 21.

Note the shoulder in each distribution, demonstrating the presence of a characteristic size and time scale, qualifying the periodic regime.

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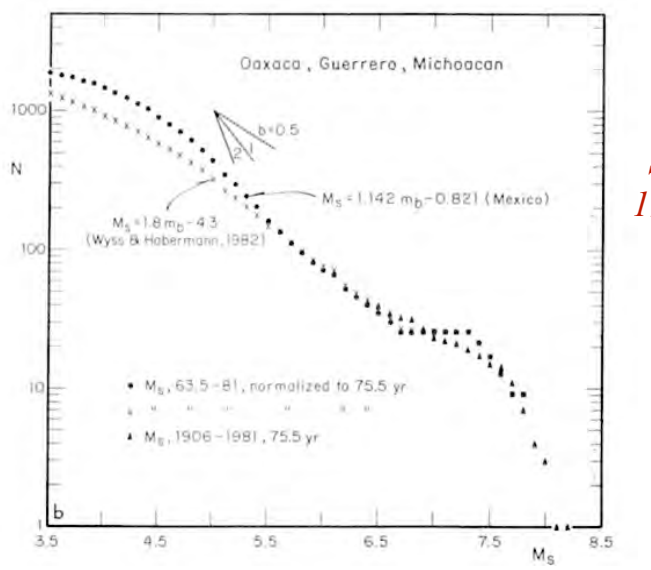
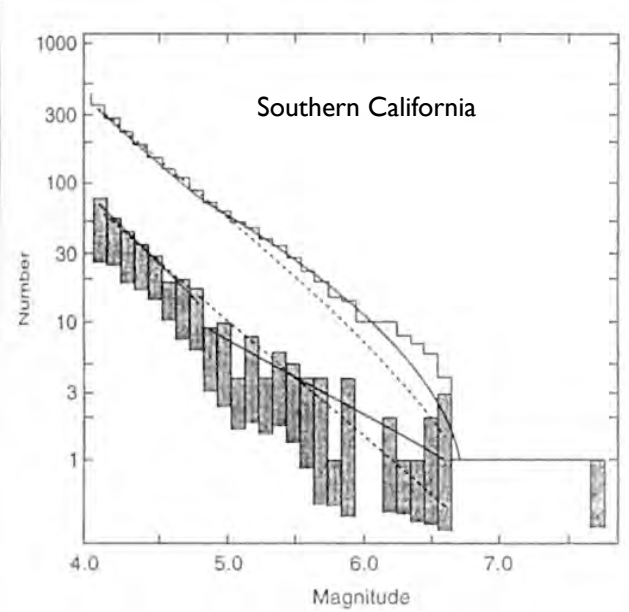
Complex magnitude distributions

Characteristic earthquakes?



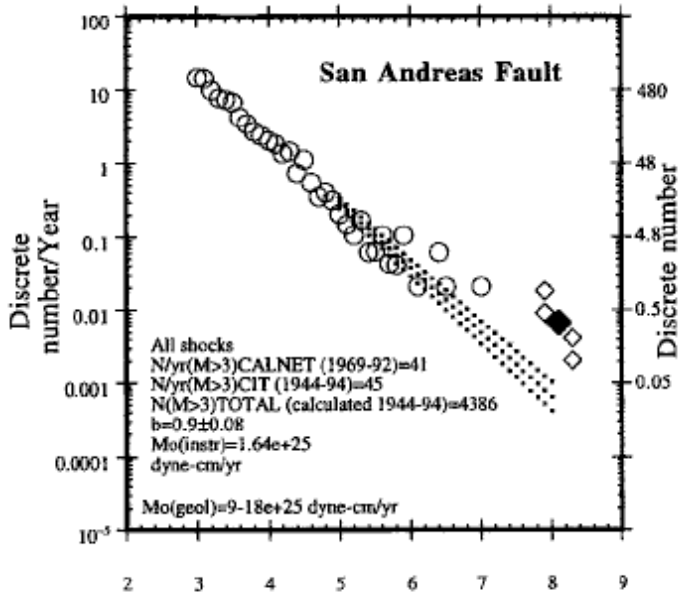
Singh, et. al., 1983, BSSA 73, 1779-1796

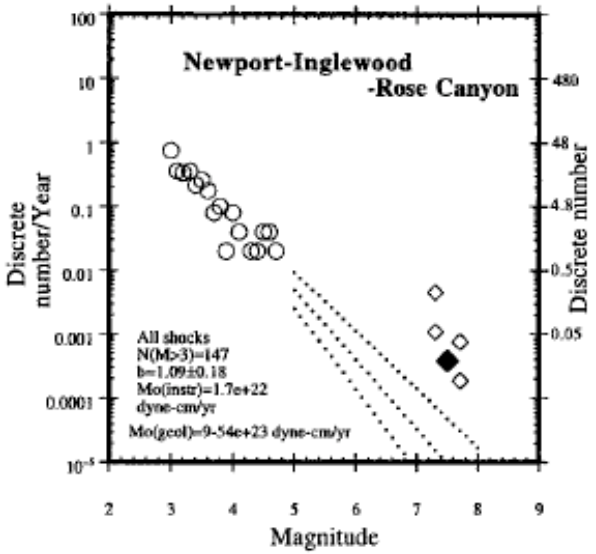


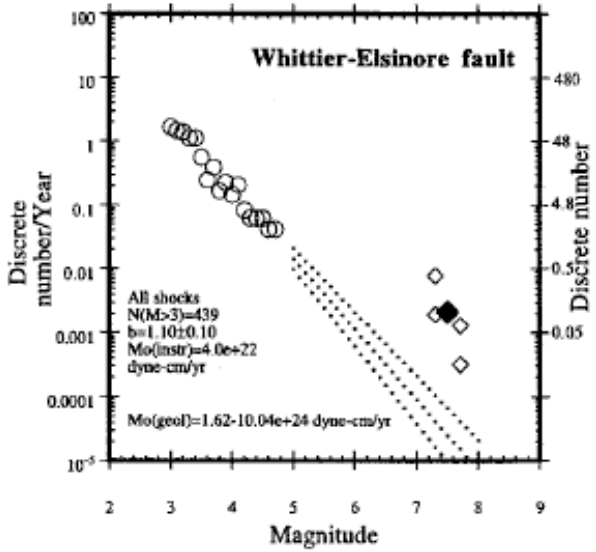
Knopoff, 2000, PNAS 97, 11880-11884

Main, 1995, BSSA 85, 1299-1308

Wesnousky, 1996, BSSA 86, 286-291



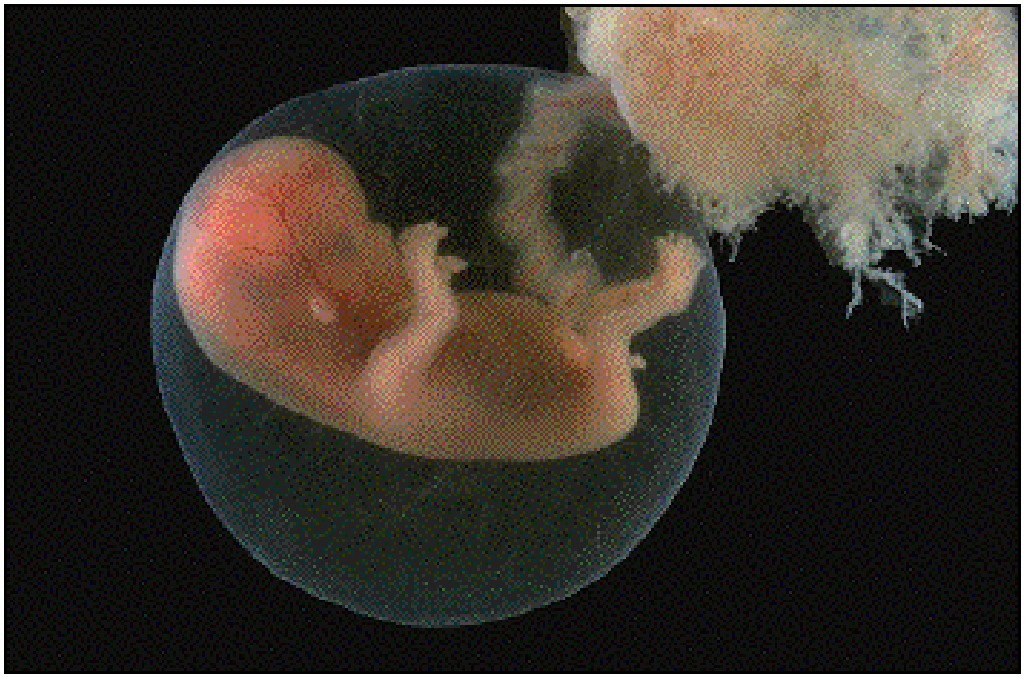




Predictability of catastrophic events: Material rupture, earthquakes, turbulence, financial crashes, and human birth

2522–2529 | PNAS | February 19, 2002 | vol. 99 | suppl. 1

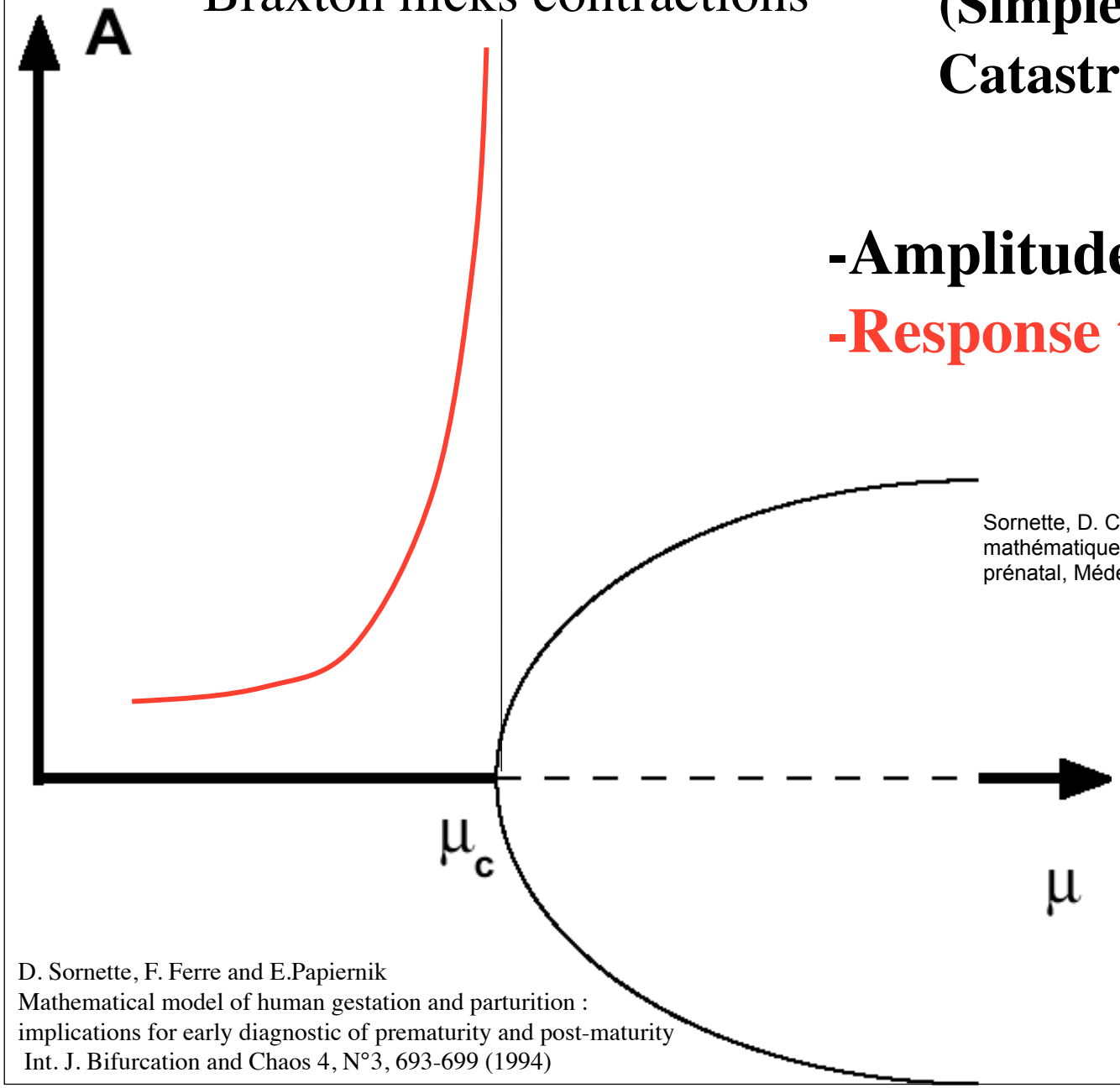
D. Sornette



Generic Critical Precursors to a Bifurcation

Braxton hicks contractions

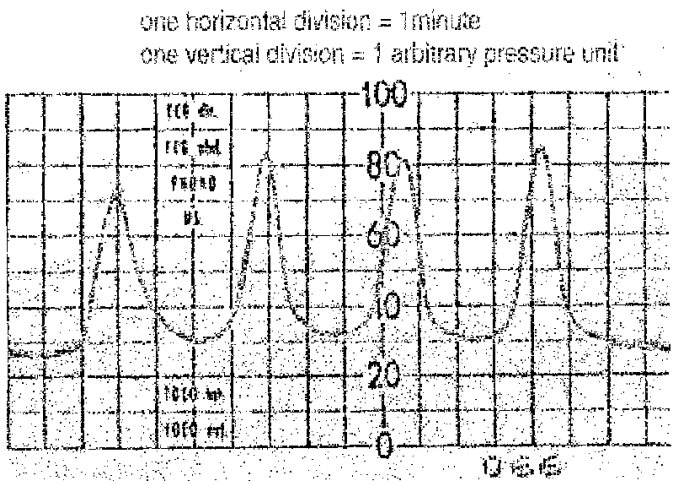
(Simple example of Catastrophe theory)



-Amplitude of fluctuations

-Response to external forcing

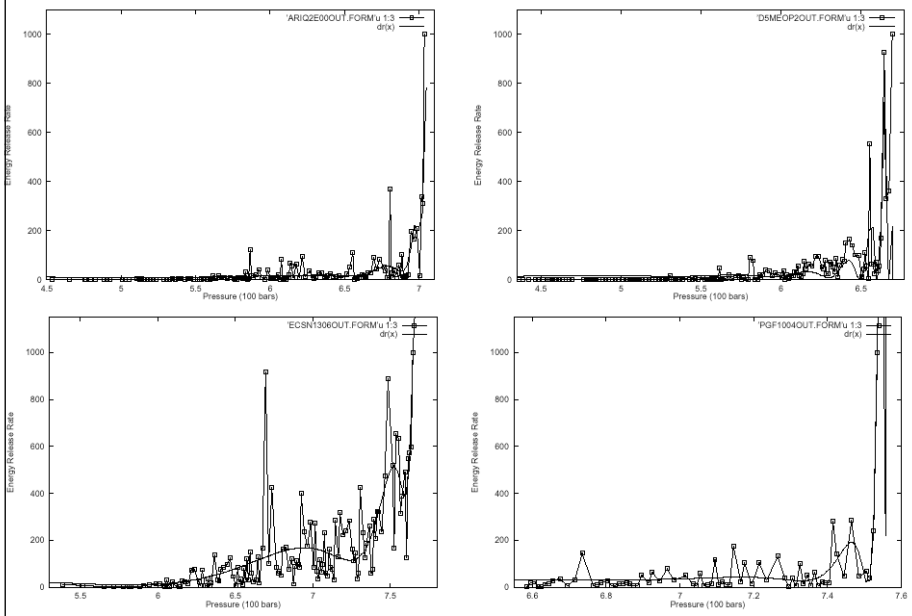
Sornette, D. Carbone, F.Ferre, C. Vauge and E.Papiernik, Modèle mathématique de la parturition humaine : implications pour le diagnostic prénatal, Médecine/Science 11, n°8, 1150-1153 (1995)



D. Sornette, F. Ferre and E.Papiernik
Mathematical model of human gestation and parturition : implications for early diagnostic of prematurity and post-maturity
Int. J. Bifurcation and Chaos 4, N°3, 693-699 (1994)

Methodology for predictability of crises

Strategy: look at the forest rather than at the tree

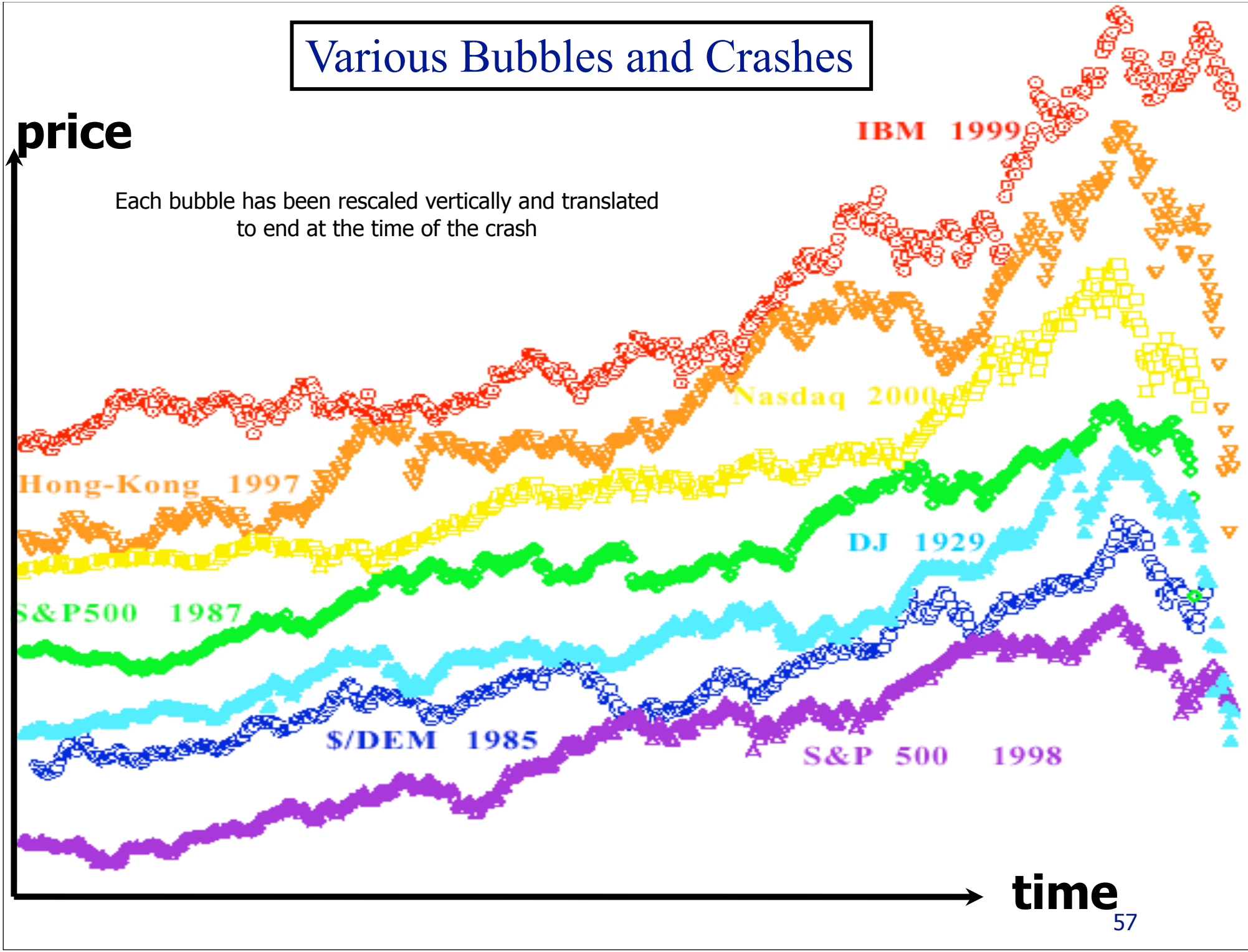


Our prediction system is now used in the industrial phase as the standard testing procedure.

EADS LAUNCH VEHICLES

J.-C. Anifrani, C. Le Floc'h, D. Sornette and B. Souillard
"Universal Log-periodic correction to renormalization group scaling for rupture stress prediction from acoustic emissions", J.Phys.I France 5, n°6, 631-638 (1995)

Various Bubbles and Crashes

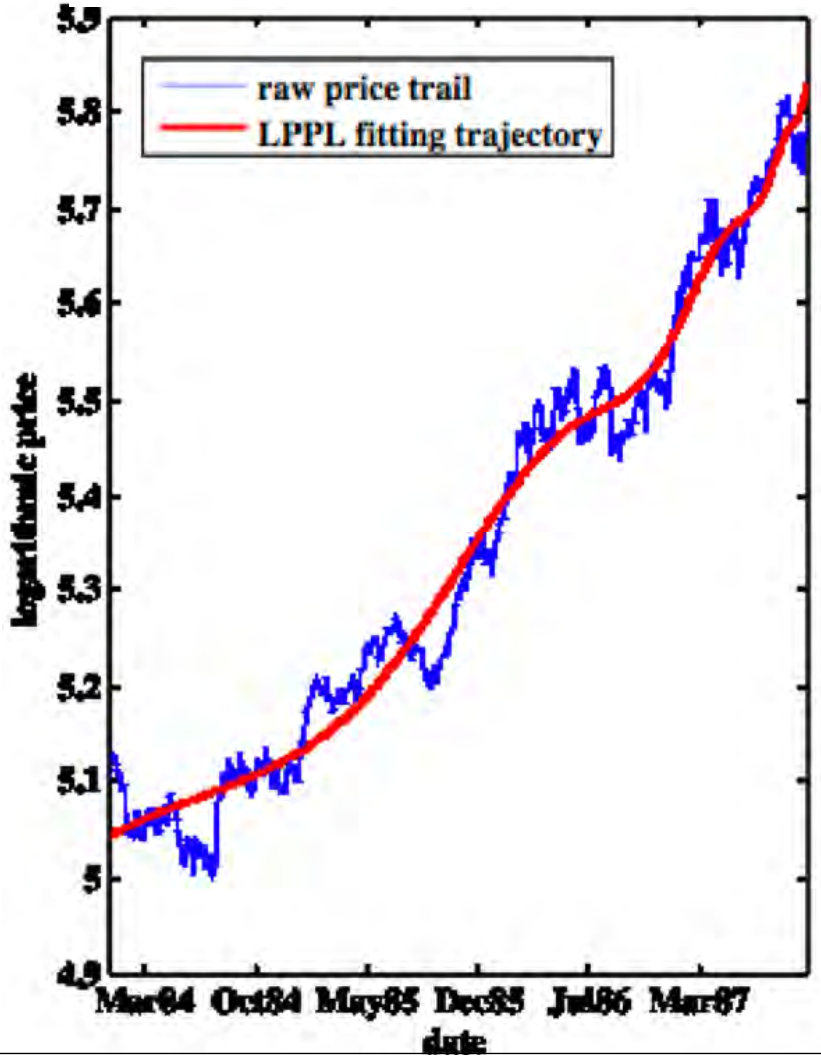


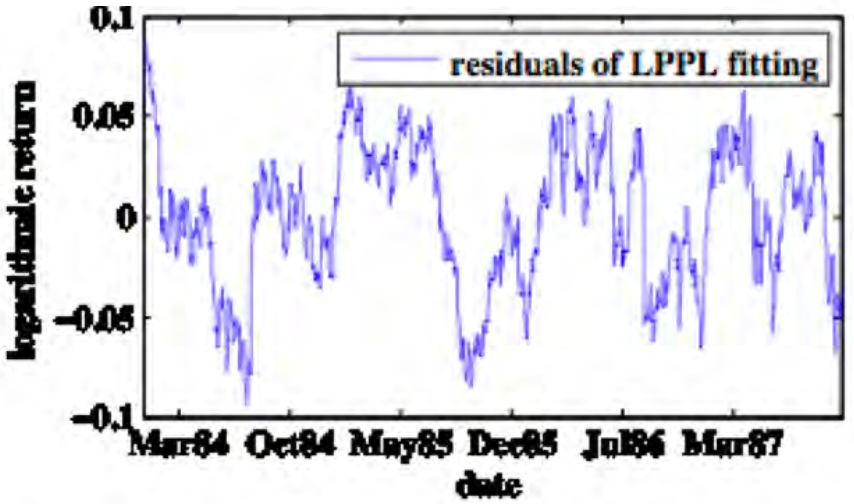
Methodology for predictability of crises

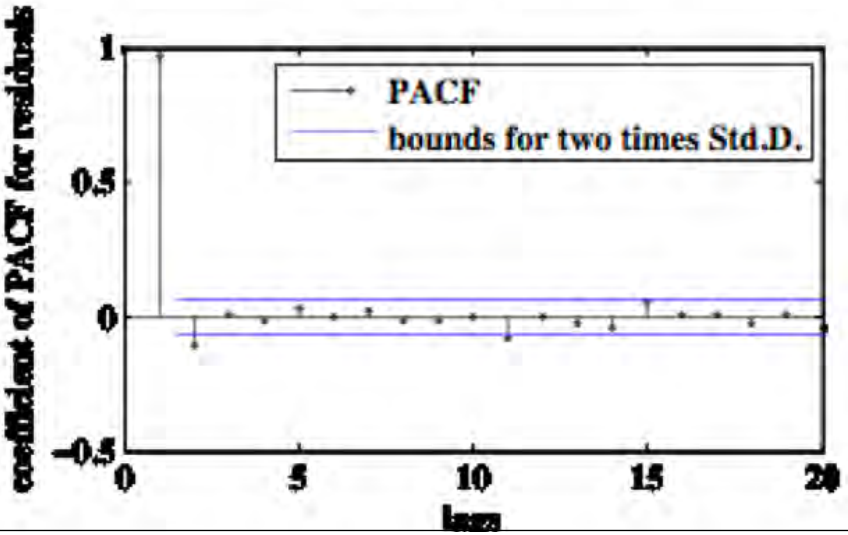
A Consistent Model of 'Explosive' Financial Bubbles With Mean-Reversing Residuals

L. Lin, R. E. Ren and D. Sornette (2009) (http://arxiv.org/abs/0905.0128)

$$\frac{dI}{I} = [r + \rho\Sigma + \kappa h(t)\,]dt - \alpha\rho_Y Y dt + (\sigma_Y + \sigma_W)dW$$







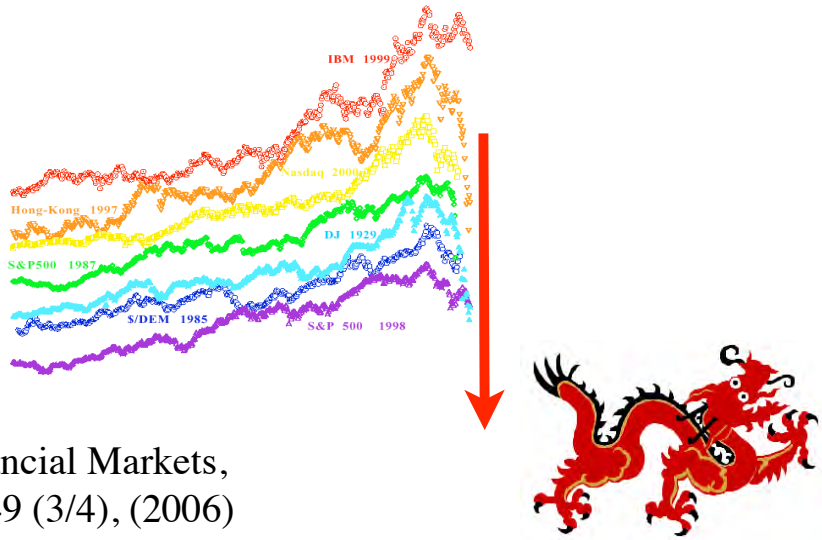
Endogenous vs exogenous crashes

1. Systematic qualification of "dragon-kings" in pdfs of drawdowns

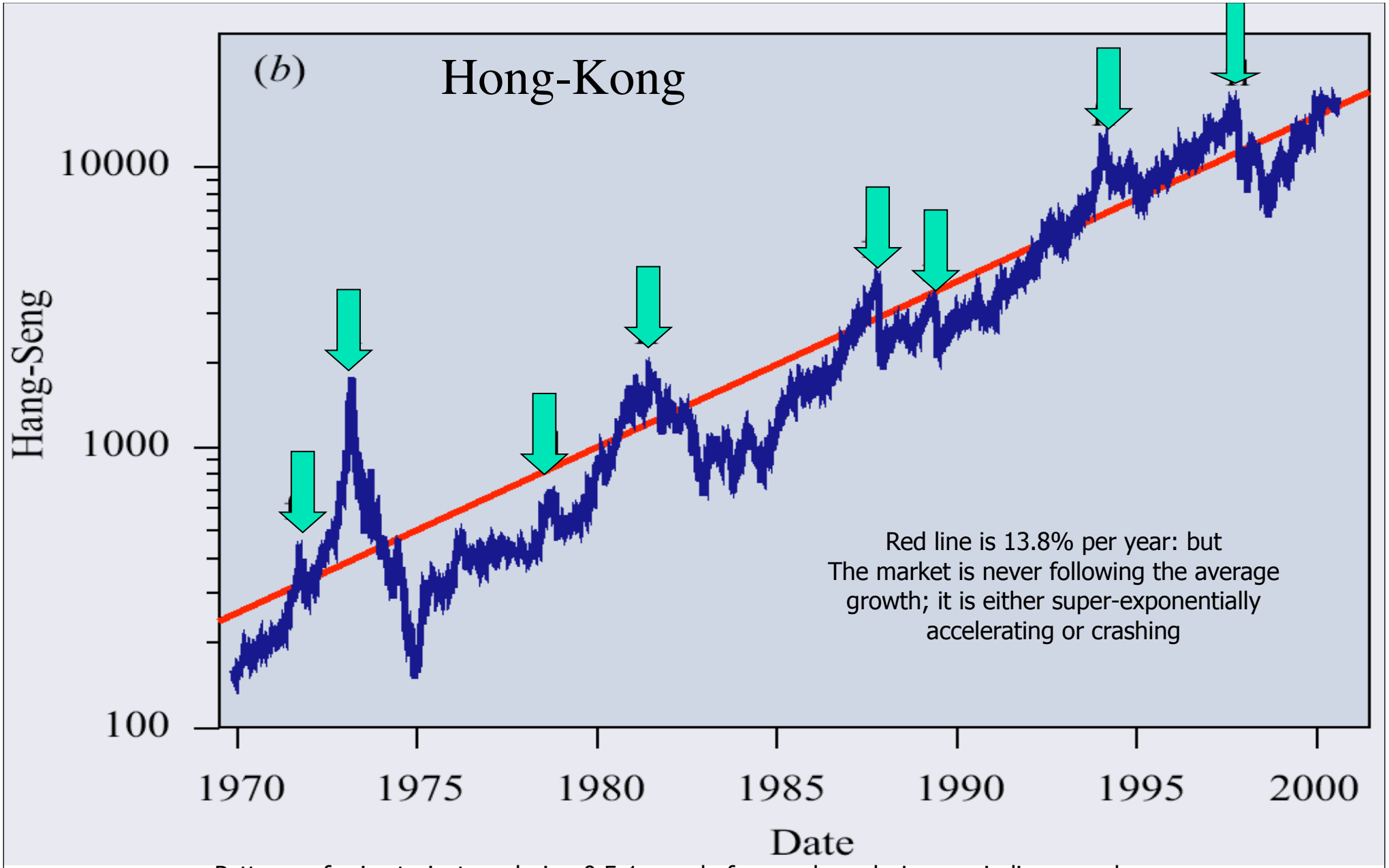
2. Existence or absence of a "critical" behavior by LPPL patterns found systematically in the price trajectories preceding this outliers

Results: In worldwide stock markets + currencies + bonds

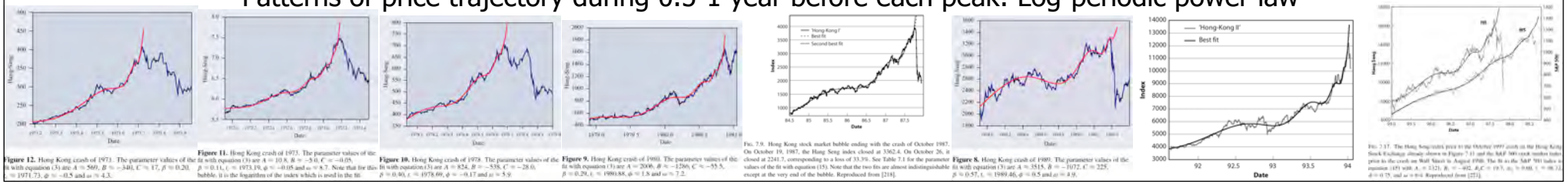
- **21 endogenous crashes**
- **10 exogenous crashes**



A. Johansen and D. Sornette, Shocks, Crashes and Bubbles in Financial Markets, Brussels Economic Review (Cahiers economiques de Bruxelles), 49 (3/4), (2006)



Patterns of price trajectory during 0.5-1 year before each peak: Log-periodic power law

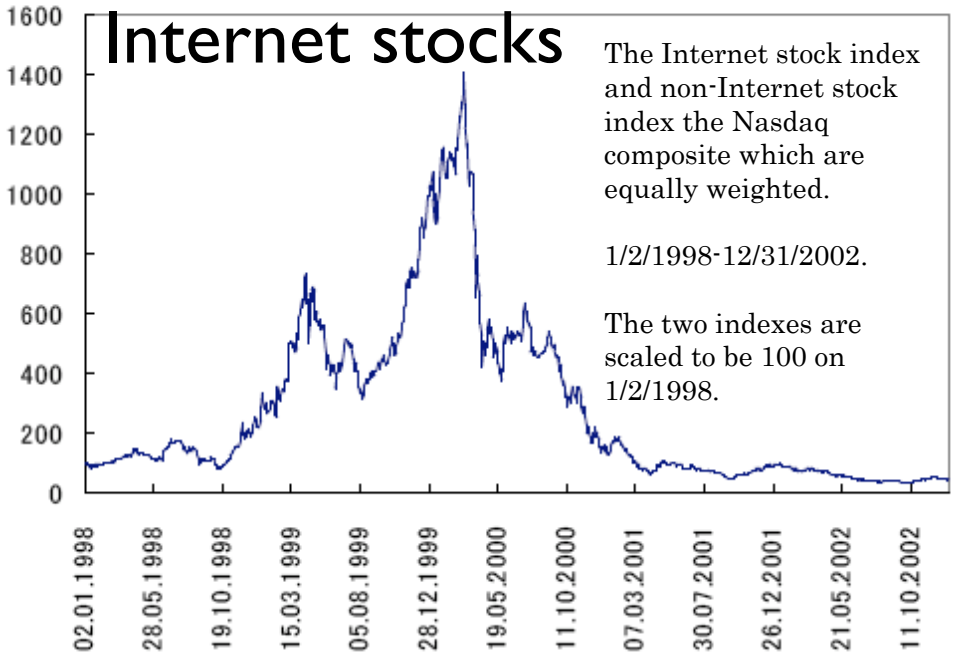


Predictability of the 2007-XXXX crisis: 15y History of bubbles and Dragon-kings

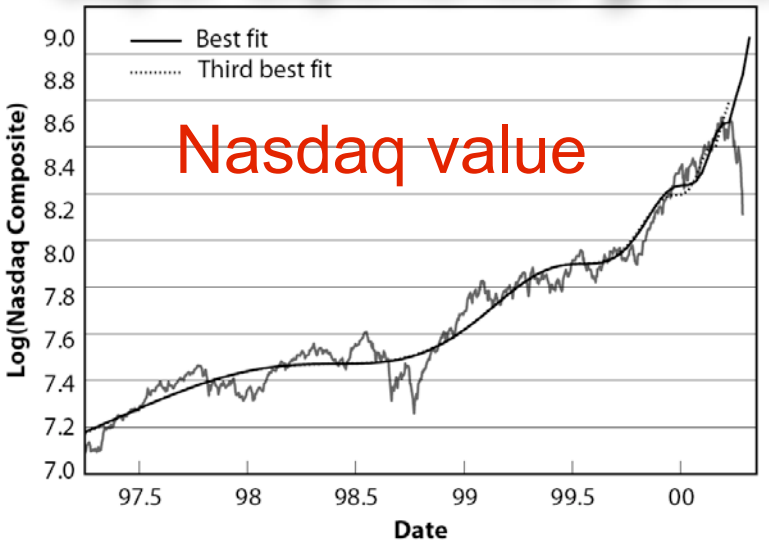
- The ITC “new economy” bubble (1995-2000)
- Slaving of the Fed monetary policy to the stock market descent (2000-2003)
- Real-estate bubbles (2003-2006)
- MBS, CDOs bubble (2004-2007) and stock market bubble (2004-2007)
- Commodities and Oil bubbles (2006-2008)

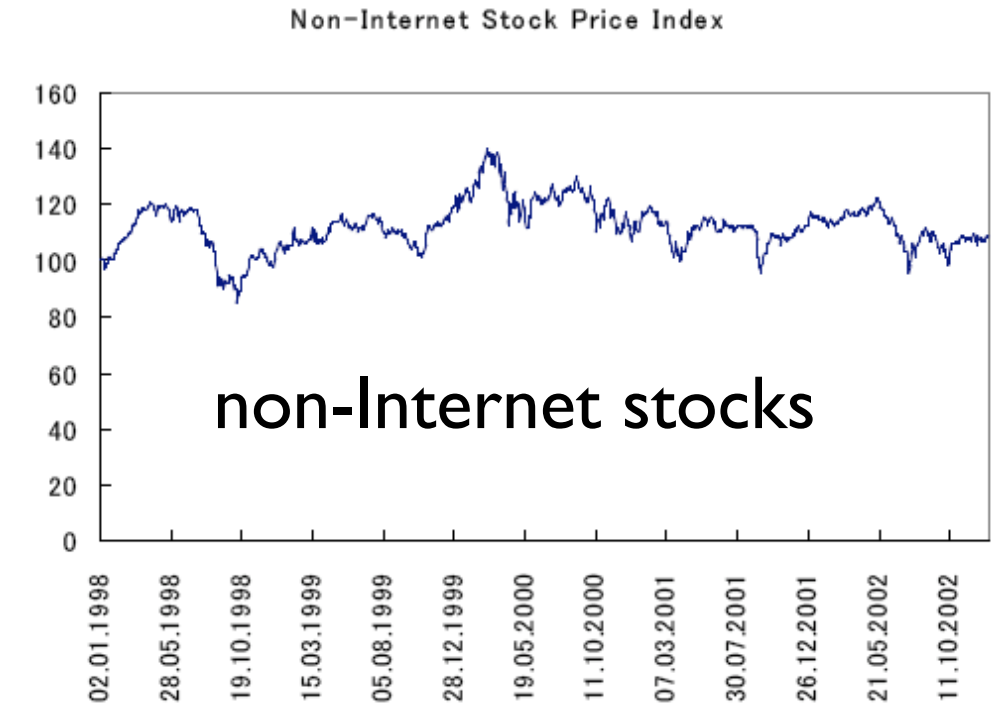
Didier Sornette and Ryan Woodard
Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis (2009)
(http://arxiv.org/abs/0905.0220)

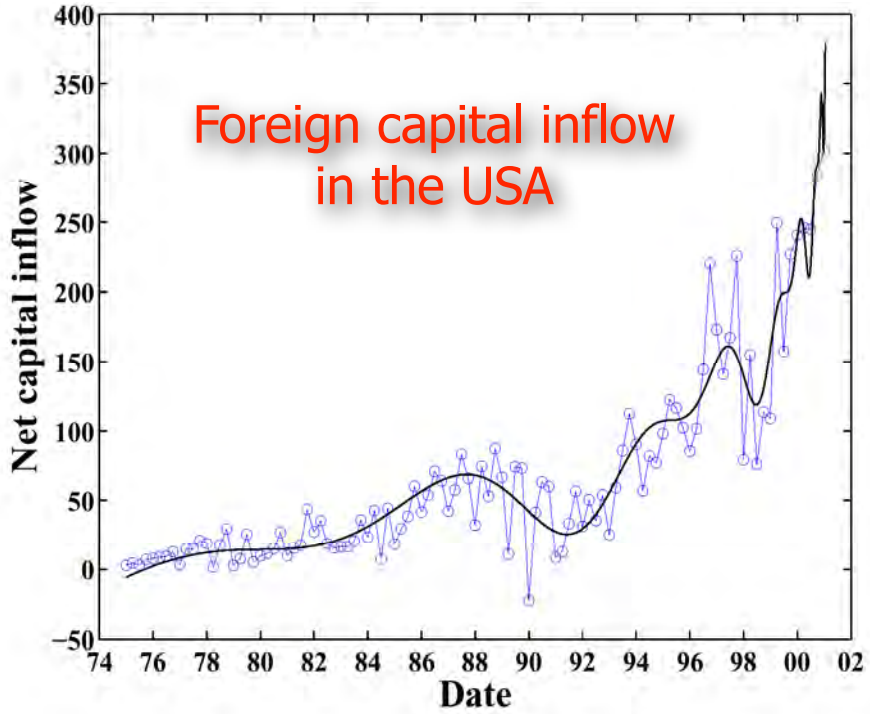
THE NASDAQ CRASH OF APRIL 2000



Super-exponential growth







Real-estate in the UK

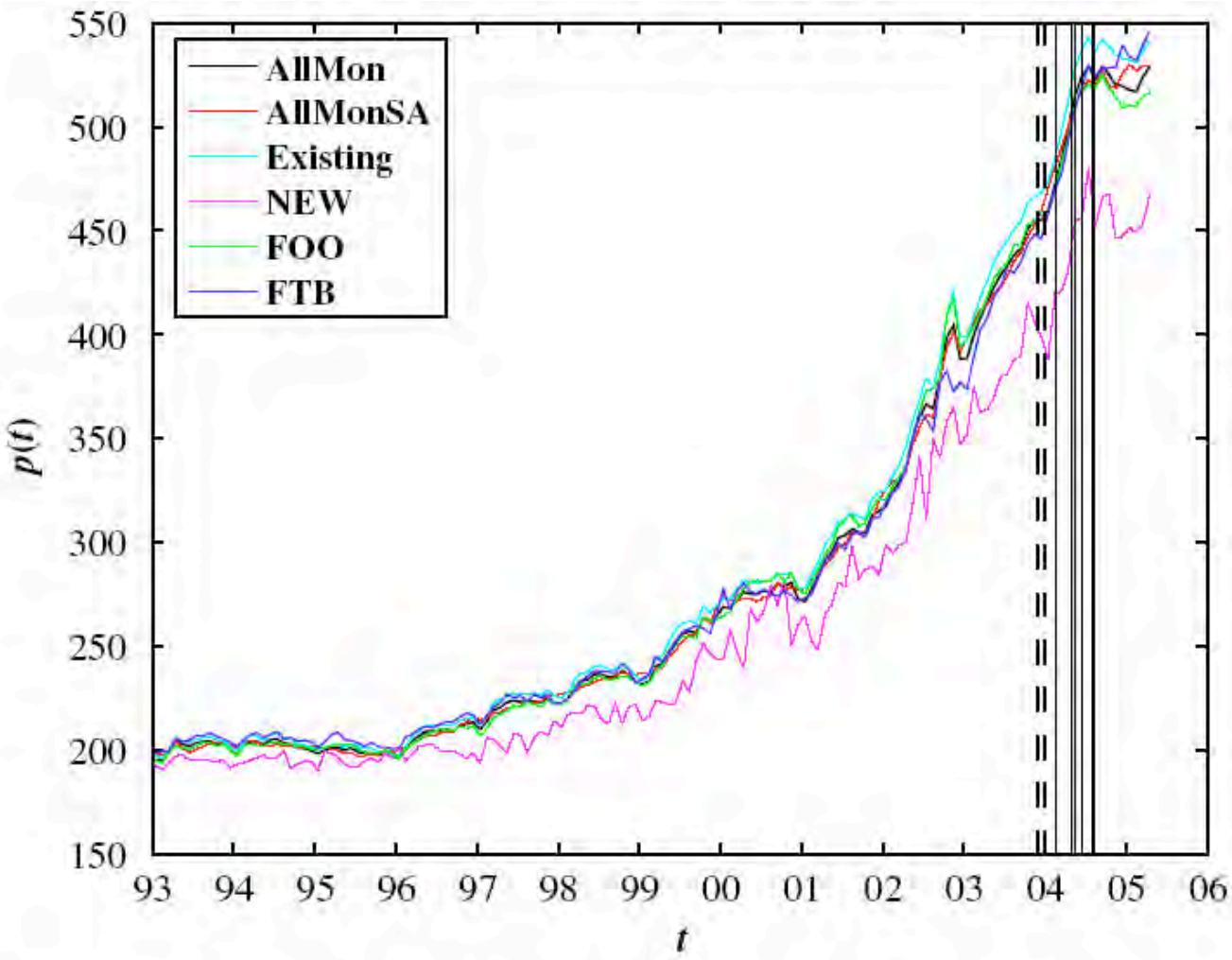


Fig. 1. (Color online) Plot of the UK Halifax house price indices from 1993 to April 2005 (the latest available quote at the time of writing). The two groups of vertical lines correspond to the two predicted turning points reported in Tables 2 and 3 of [1]: end of 2003 and mid-2004. The former (resp. later) was based on the use of formula (2) (resp. (3)). These predictions were performed in February 2003.

W.-X. Zhou, D. Sornette, 2000–2003 real estate bubble in the UK but not in the USA, Physica A 329 (2003) 249–263.

Real-estate in the USA

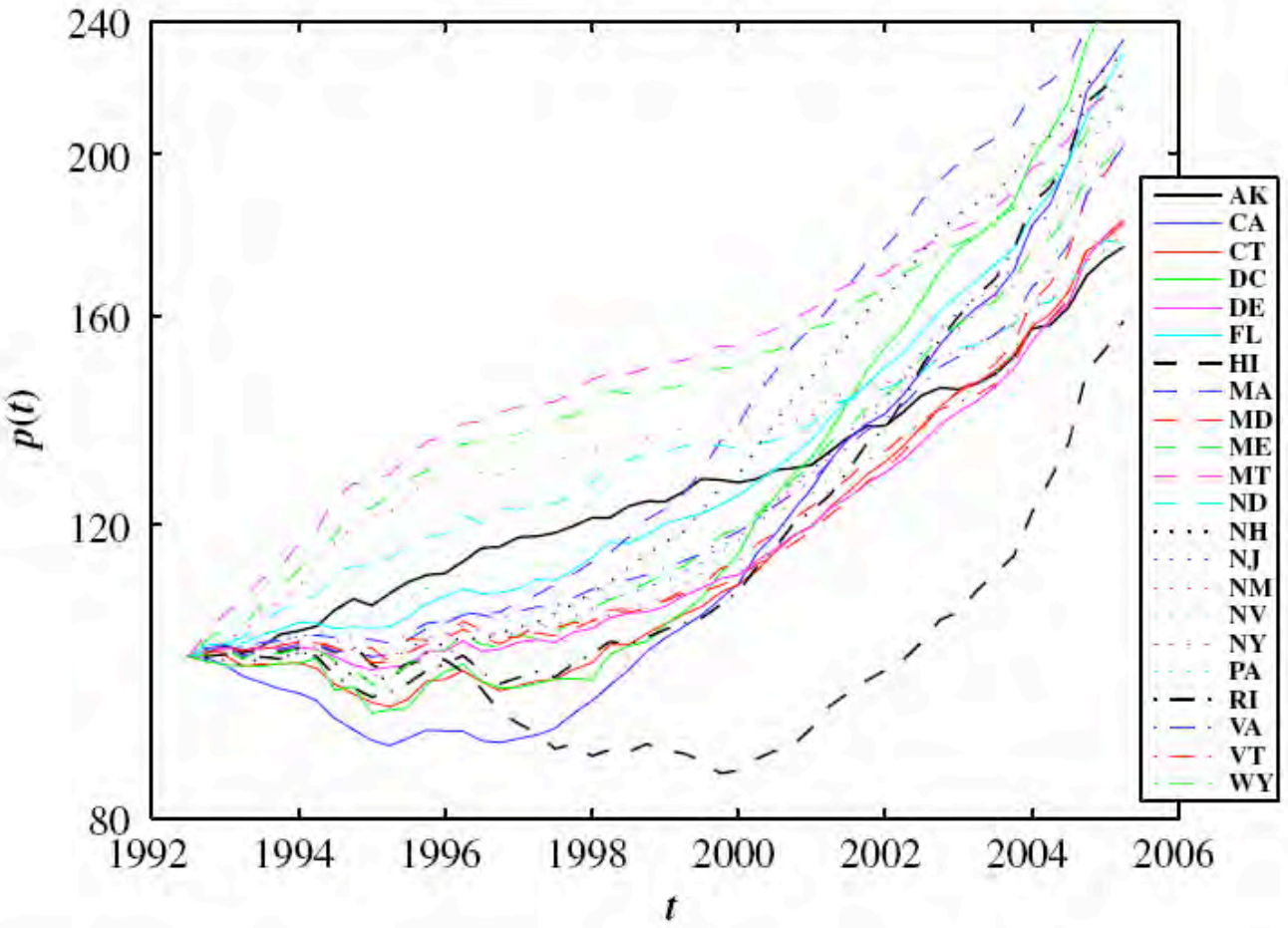
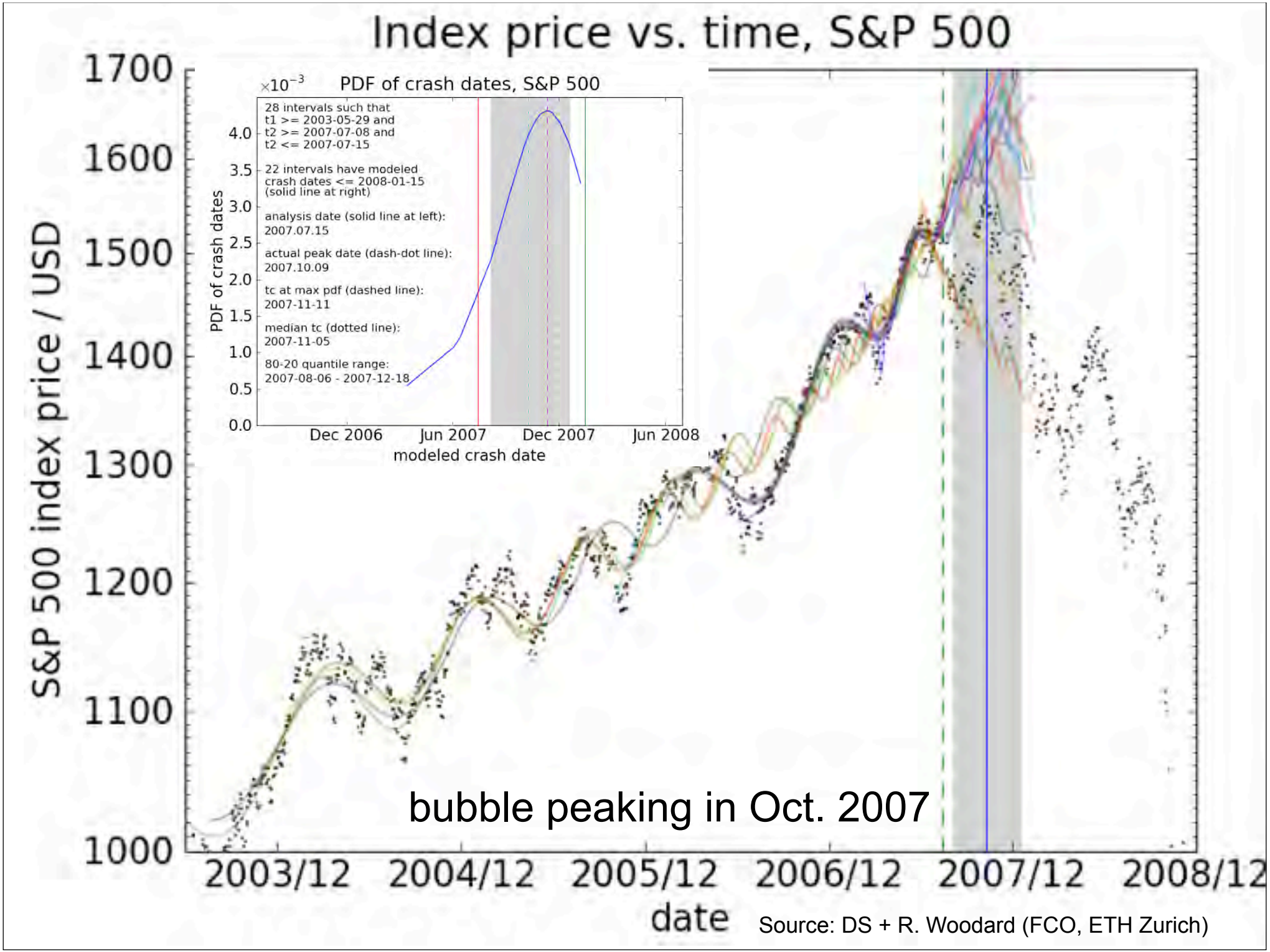
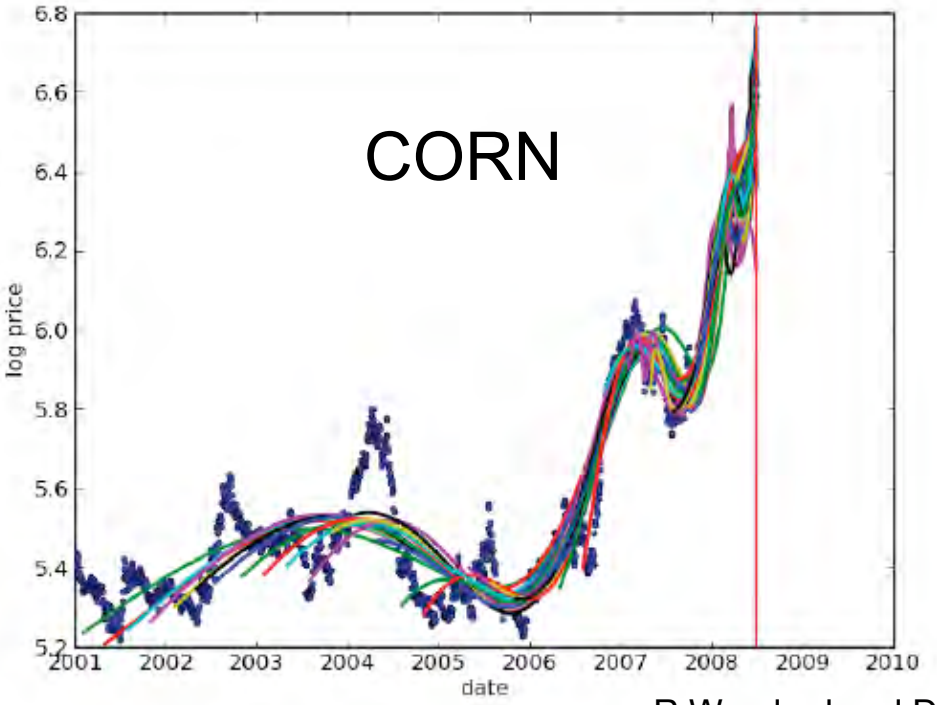
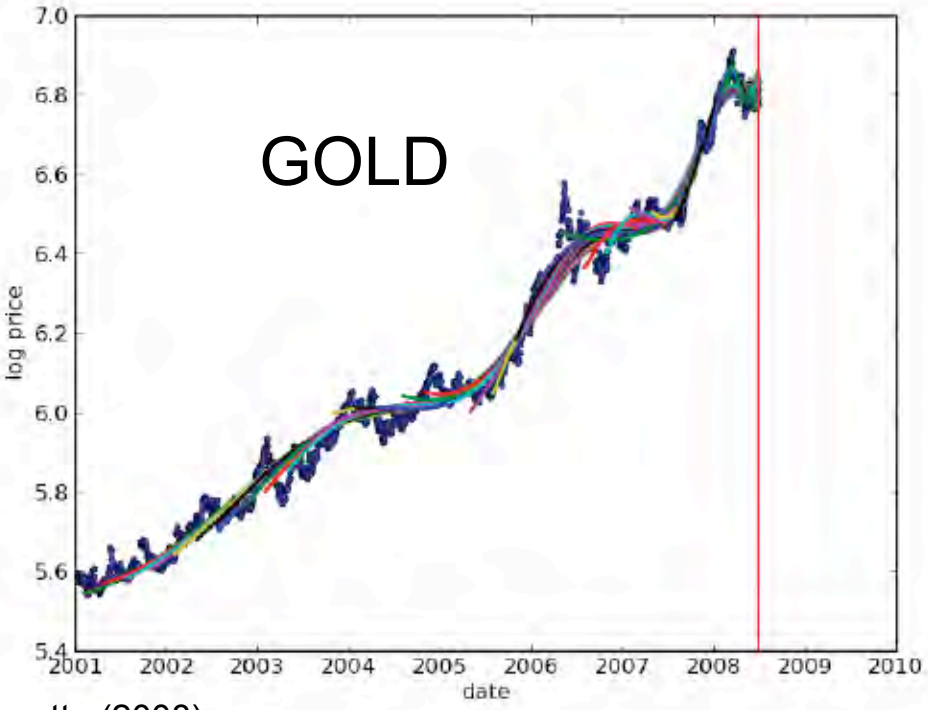


Fig. 5. (Color online) Quarterly average HPI in the 21 states and in the District of Columbia (DC) exhibiting a clear upward faster-than-exponential growth. For better representation, we have normalized the house price indices for the second quarter of 1992 to 100 in all 22 cases. The corresponding states are given in the legend.

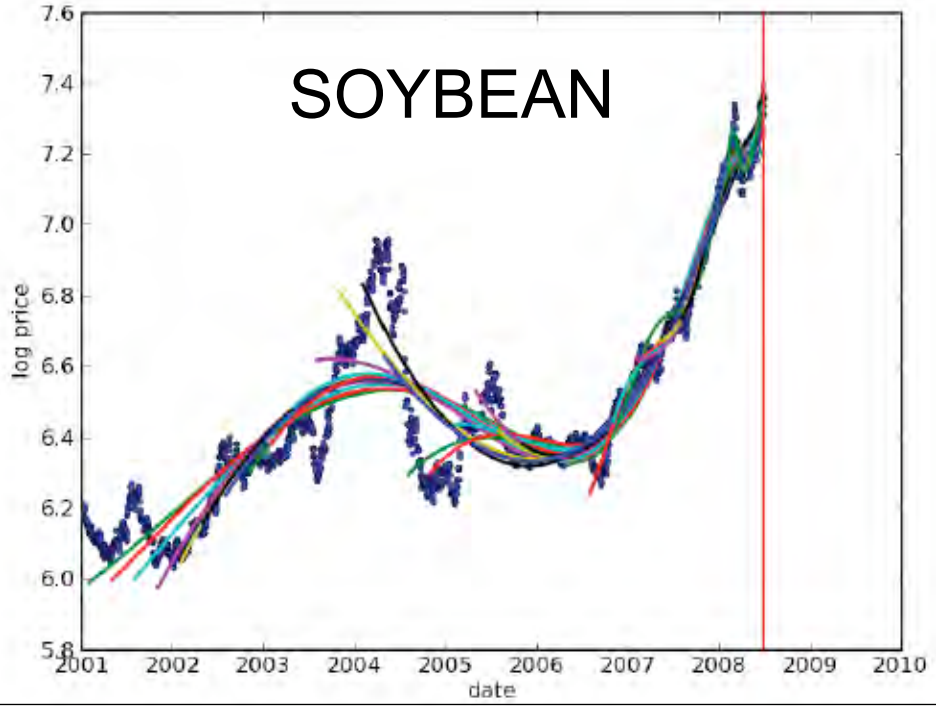
W.-X. Zhou, D. Sornette / Physica A 361 (2006) 297–308

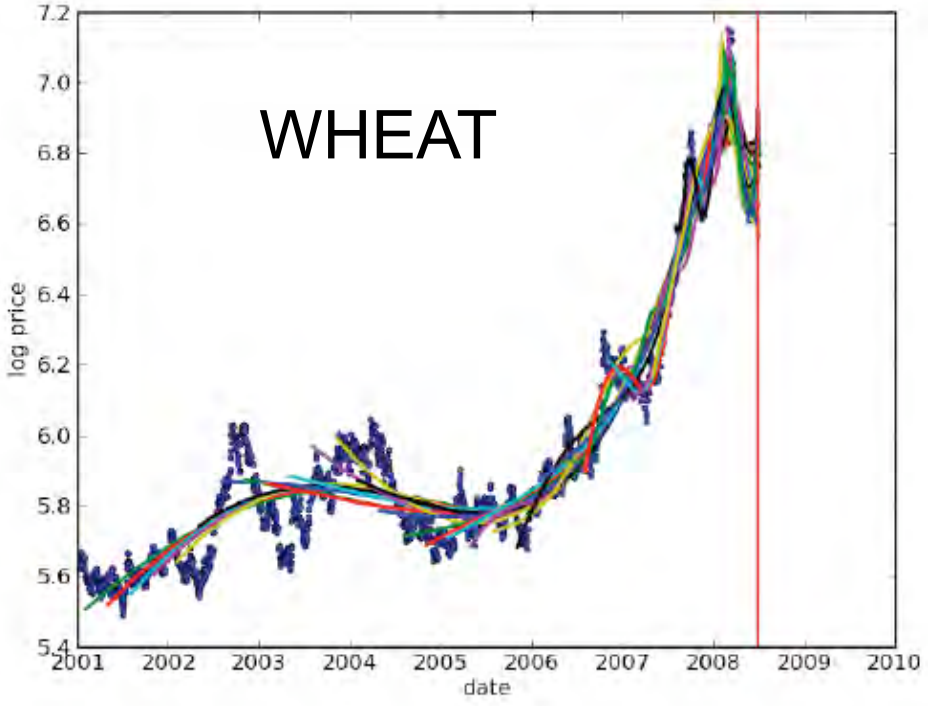

Index price vs. time, S&P 500
S&P 500 index price / USD
1700
1600
1500
1400
1300
1200
1100
1000
2003/12
2004/12
2005/12
2006/12
2007/12
2008/12
date
PDF of crash dates, S&P 500
×10^−3
PDF of crash dates
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
28 intervals such that
t1 >= 2003-05-29 and
t2 >= 2007-07-08 and
t2 <= 2007-07-15
22 intervals have modeled
crash dates <= 2008-01-15
(solid line at right)
analysis date (solid line at left):
2007.07.15
actual peak date (dash-dot line):
2007.10.09
tc at max pdf (dashed line):
2007-11-11
median tc (dotted line):
2007-11-05
80-20 quantile range:
2007-08-06 - 2007-12-18
Dec 2006
Jun 2007
Dec 2007
Jun 2008
modeled crash date
bubble peaking in Oct. 2007
Source: DS + R. Woodard (FCO, ETH Zurich)





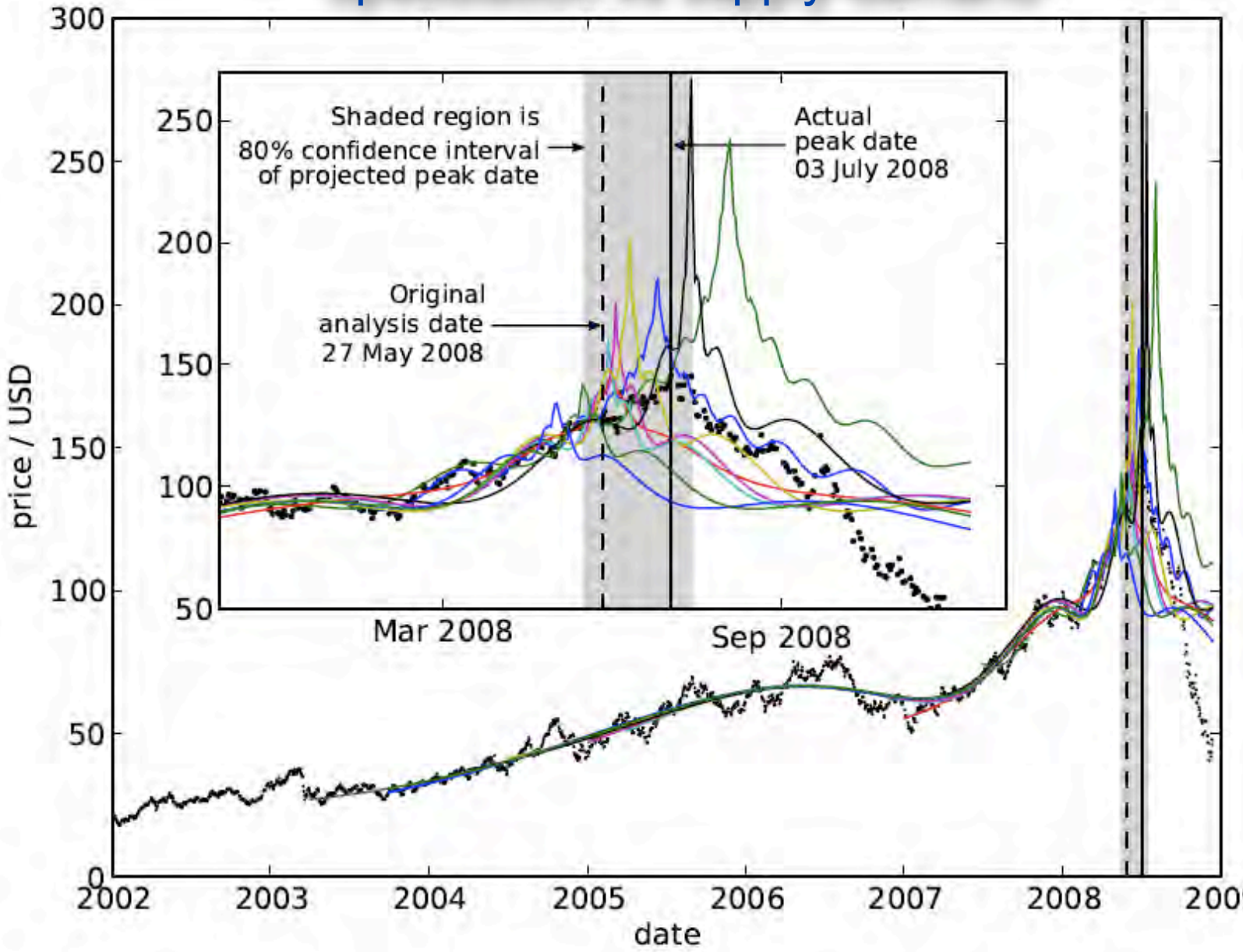
R.Woodard and D.Sornette (2008)





2006-2008 Oil bubble

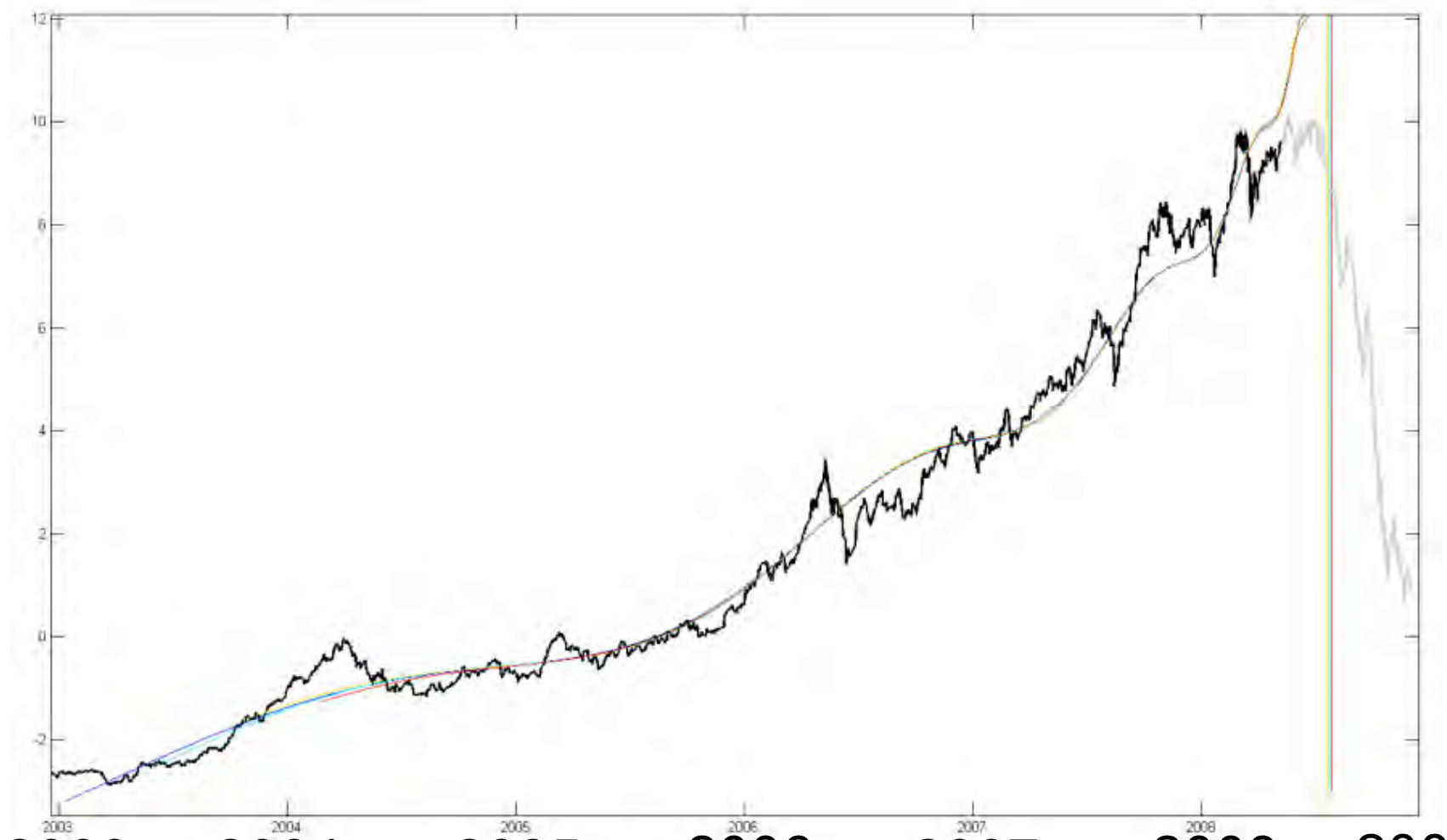
Speculation vs supply-demand



D. Sornette, R. Woodard and W.-X. Zhou, The 2006-2008 Oil Bubble and Beyond, Physica A 388, 1571-1576 (2009) (arXiv.org/abs/0806.1170)

Typical result of the calibration of the simple LPPL model to the oil price in US$ in shrinking windows with starting dates t_{start} moving up towards the common last date t_{last} = May 27, 2008.

The Global BUBBLE



PCA first component on a data set containing, emerging markets equity indices, freight indices, soft commodities, base and precious metals, energy, currencies...

(Peter Cauwels FORTIS BANK - Global Markets)

Chinese Equity Bubble: burst in August 2009

K. Bastiaensen, P. Cauwels, D. Sornette, R. Woodard and W.-X. Zhou

July 10, 2009 (http://arxiv.org/abs/0907.1827)

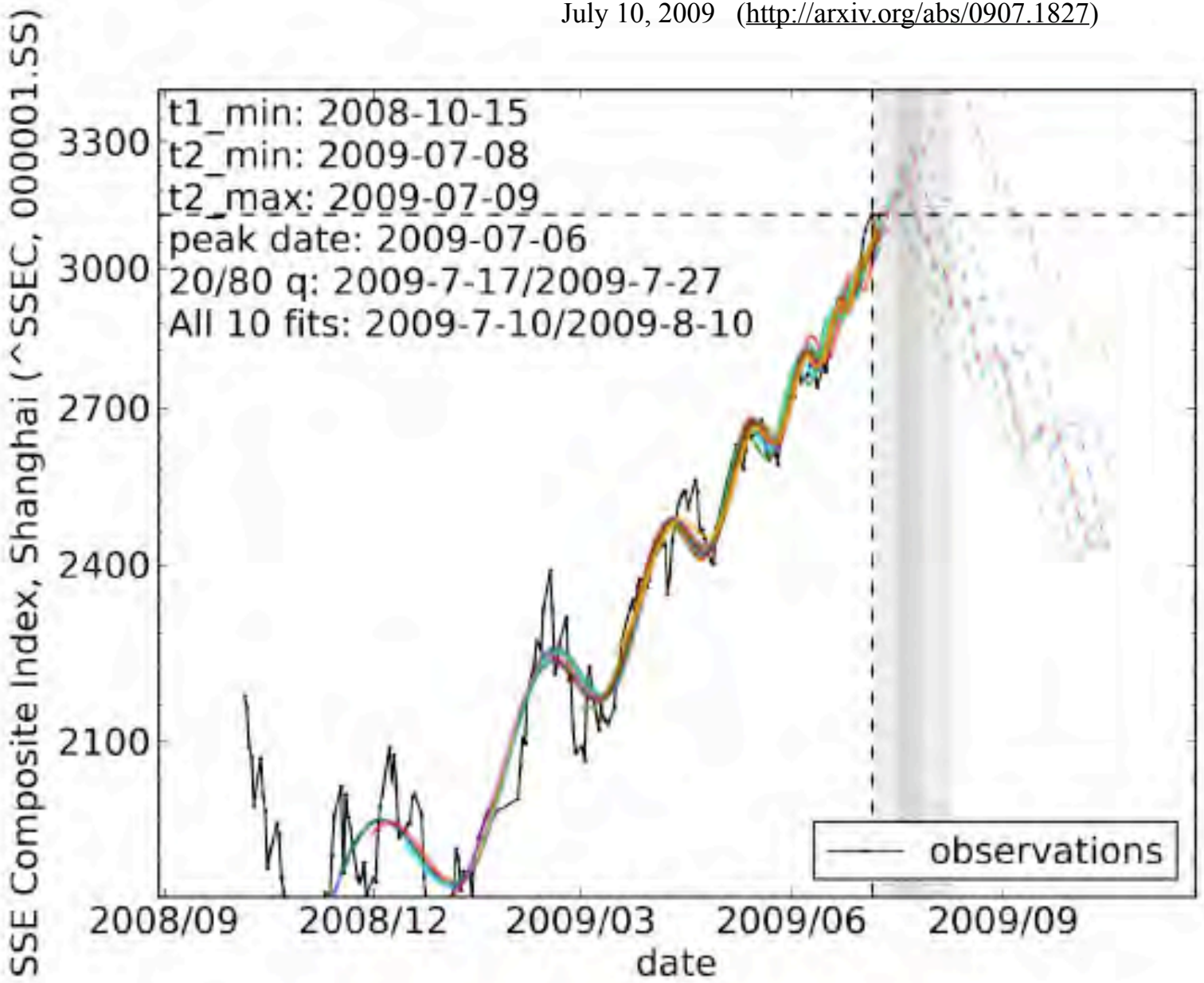
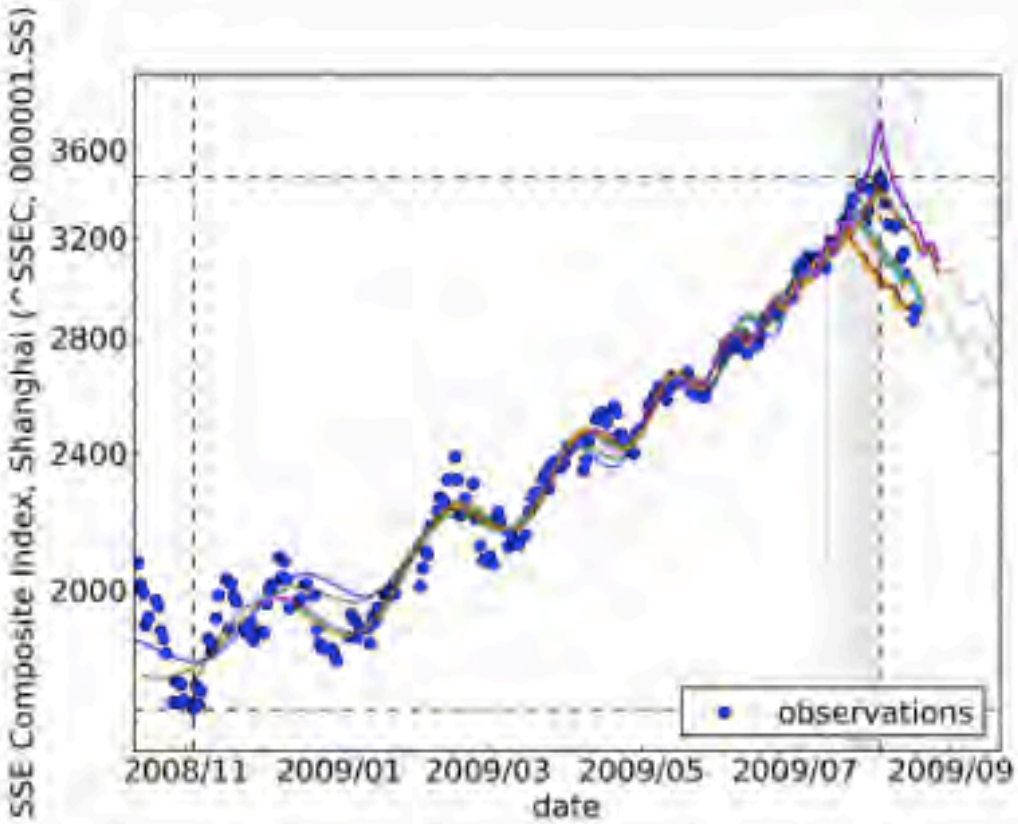


Figure 1: Shanghai Composite Index with LPPL result.

FCO@ETH: Towards operational science of financial instabilities

Didier Sornette, Maxim Fedorovsky, Stefan Riemann, Hilary Woodard, Ryan Woodard, Wanfeng Yan, Wei-Xing Zhou

- Main mission:
  - Identify bubbles
- Theory:
  - Positive feedback
- Deliverables
  - Weekly global bubble scan
  - Research, papers
  - Public forecasts
  - Digital timestamps



ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Departement Management, Technology, and Economics
MTEC

Entrepreneurial Risks

The Financial Bubble Experiment
First Results (2 November 2009 - 3 May 2010)

D. Sornette, R. Woodard, M. Fedorovsky, S. Reimann, H. Woodard, W.-X. Zhou
(The Financial Crisis Observatory)
Department of Management, Technology and Economics,
ETH Zurich, Kreuzplatz 5, CH-8032 Zurich, Switzerland

WHAT IS A BUBBLE?

Academic Literature: No consensus on what is a bubble...

Ex: Refet S. Gürkaynak, Econometric Tests of Asset Price Bubbles: Taking Stock (2008)
For each paper that finds evidence of bubbles, there is another one that fits the data equally well without allowing for a bubble.
We are still unable to distinguish bubbles from time-varying or regime-switching fundamentals, while many small sample econometrics problems of bubble tests remain unresolved.

Professional Literature: we do not know... only after the crash

The Fed: A. Greenspan (Aug., 30, 2002):
"We, at the Federal Reserve…recognized that, despite our suspicions, it was very difficult to definitively identify a bubble until after the fact, that is, when its bursting confirmed its existence… Moreover, it was far from obvious that bubbles, even if identified early, could be preempted short of the Central Bank inducing a substantial contraction in economic activity, the very outcome we would be seeking to avoid."

THE FINANCIAL BUBBLE EXPERIMENT
advanced diagnostics and forecasts of bubble ends

- ***Hypothesis H1*: financial (and other) bubbles can be diagnosed in real-time before they end.**

- ***Hypothesis H2*: The termination *(regime change)* of financial (and other) bubbles can be bracketed using probabilistic forecasts, with a reliability better than chance.**

Methodology for diagnosing bubbles

- Positive feedbacks of higher return anticipation
  - Super exponential price
  - Power law “Finite-time singularity”

- Negative feedback spirals of crash expectation
  - Accelerating large-scale financial volatility
  - Log-periodic discrete scale-invariant patterns

The Financial Bubble Experiment: advanced diagnostics and forecasts of bubble terminations

D. Sornette, R. Woodard, M. Fedorovsky, S. Reimann, H. Woodard, W.-X. Zhou
(The Financial Crisis Observatory)*
Department of Management, Technology and Economics,
ETH Zurich, Kreuzplatz 5, CH-8032 Zurich, Switzerland

Publication date	MD5SUM SHA256SUM SHA512SUM
2009-11-02	6d9479eb2849115a12c219cfa902990e d7ad5c9531166917ba97f871fb61bd1f6290b4b4ce54e3ba0c26b42e2661dc06 808bbfaddbca3db8d0f55d74cabedf5201ecd70340f86e27dfac589ce682144f52f6fc4b3ff1ac75231038d86dae58bd320e7fb17ef321b4bc61a19e88071039
2009-11-02	5d375b742a9955d4aeea1bd5c7220b2b 5a9c395b9ab1d2014729ac5ff3bb22a352e14096fa43c59836ea0d4ae0e3b453 e7ef9150b4738253f4021b0600eff1cd455b2671e421b788b9268b518439b56699994b3f8b395742bdc7622b5536034e74ade86e0a46bff71ed5ff9a293f809f
2009-11-02	fd85000d0ce3231892ef1257d2f7ab1e d3f3d504d85d50eb3dc0fe2c3042746db2f010509f4d1717370d14012972e86f 91a8fa82b7f08deea2df2a1f7cef266f5aa155bb0c047f65b14315f7229d92976cc7b30453453fb8ecd0350783907c83652192d32ba90fb1cce128385832e63a

TABLE I: Checksums of Financial Bubble Experiment forecast documents.

arXiv:0911.0454v1 [q-fin.CP] 2 Nov 2009

Checksums of forecast documents

Publication date Document name Asset	MD5SUM SHA256SUM SHA512SUM
2009-11-02 fbe_001.pdf IBOVESPA (Brazil)	6d9479eb2849115a12c219cfa902990e d7ad5c9531166917ba97f871fb61bd1f6290b4b4ce54e3ba0c26b42e2661dc06 808bbfaddbca3db8d0f55d74cabedf5201ecd70340f86e27dfac589ce682144f52f6fc4b3ff1ac75231038d86dae58bd320e7fb17ef321b4bc61a19e88071039
2009-11-02 fbe_002.pdf ML Corp. Non-Fin. Index	5d375b742a9955d4aeea1bd5c7220b2b 5a9c395b9ab1d2014729ac5ff3bb22a352e14096fa43c59836ea0d4ae0e3b453 e7ef9150b4738253f4021b0600eff1cd455b2671e421b788b9268b518439b56699994b3f8b395742bdc7622b5536034e74ade86e0a46bff71ed5ff9a293f809f
2009-11-02 fbe_003.pdf Gold spot price (USD)	fd85000d0ce3231892ef1257d2f7ab1e d3f3d504d85d50eb3dc0fe2c3042746db2f010509f4d1717370d14012972e86f 91a8fa82b7f08deea2df2a1f7cef266f5aa155bb0c047f65b14315f7229d92976cc7b30453453fb8ecd0350783907c83652192d32ba90fb1cce128385832e63a
2009-12-23 fbe_004.pdf Cotton futures (USD)	8e019304004ebf06df17384ff664ff57 27c650d85a802eafecd8389391c440458816ff13b5c573bab710e3b7739f2e38 388fa7941c691fe7c8887886a932dd6a6aa28a967b5b05bf3cf96cdb836b499f354a78bca67d86aa246985b80e75670c3bd6300f6f4f92ca3bd0b59ac675e1eb

Brazil IBOVESPA

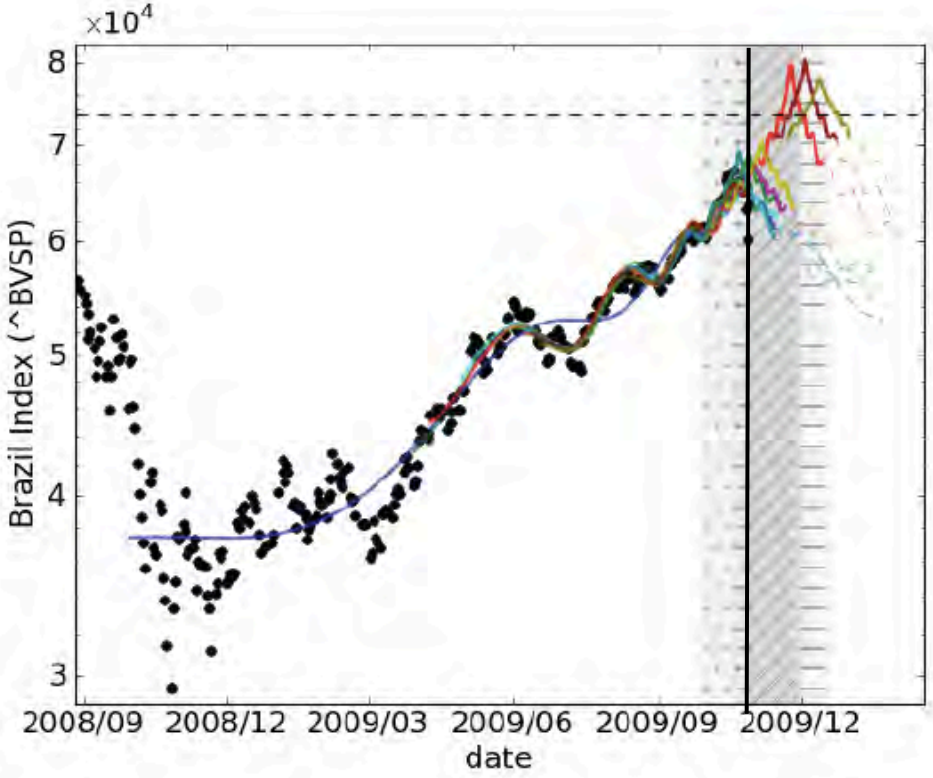
Gold spot price - USD

Merrill Lynch European Bond Index

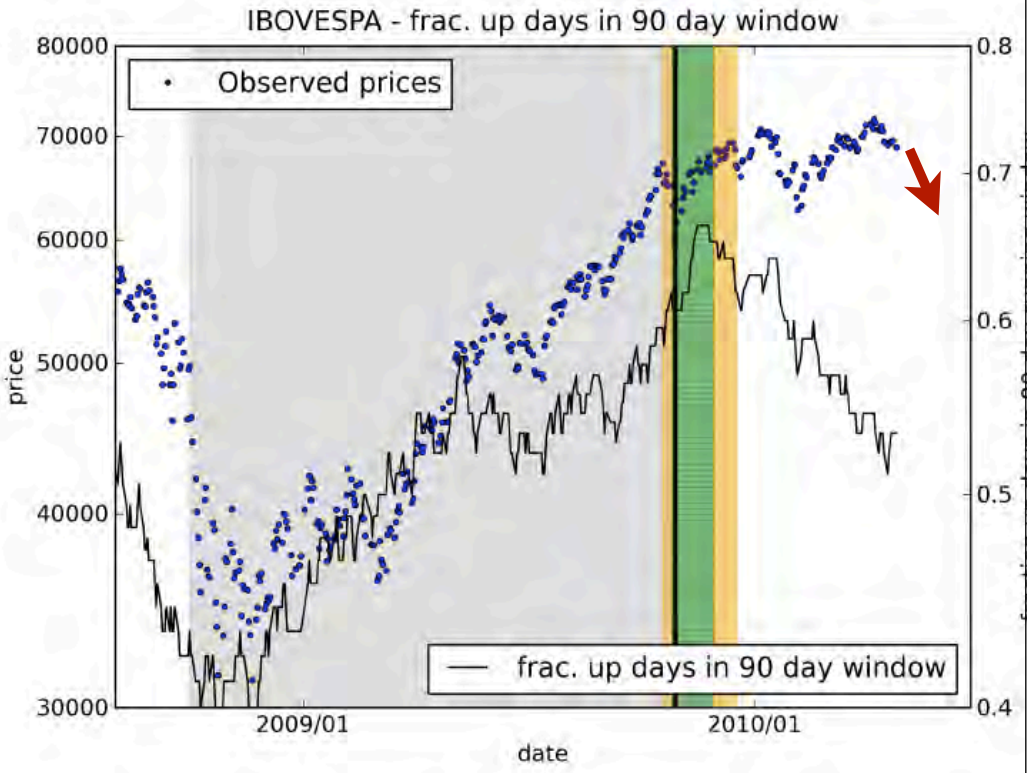
Cotton future - USD

Brazil IBOVESPA

Forecast

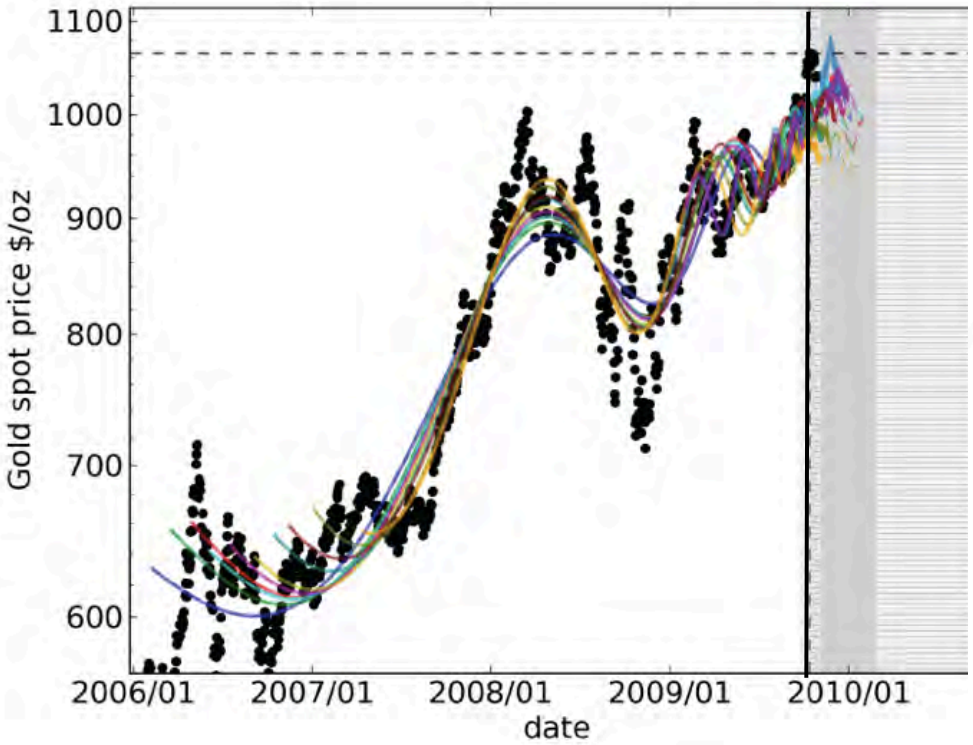


Realized

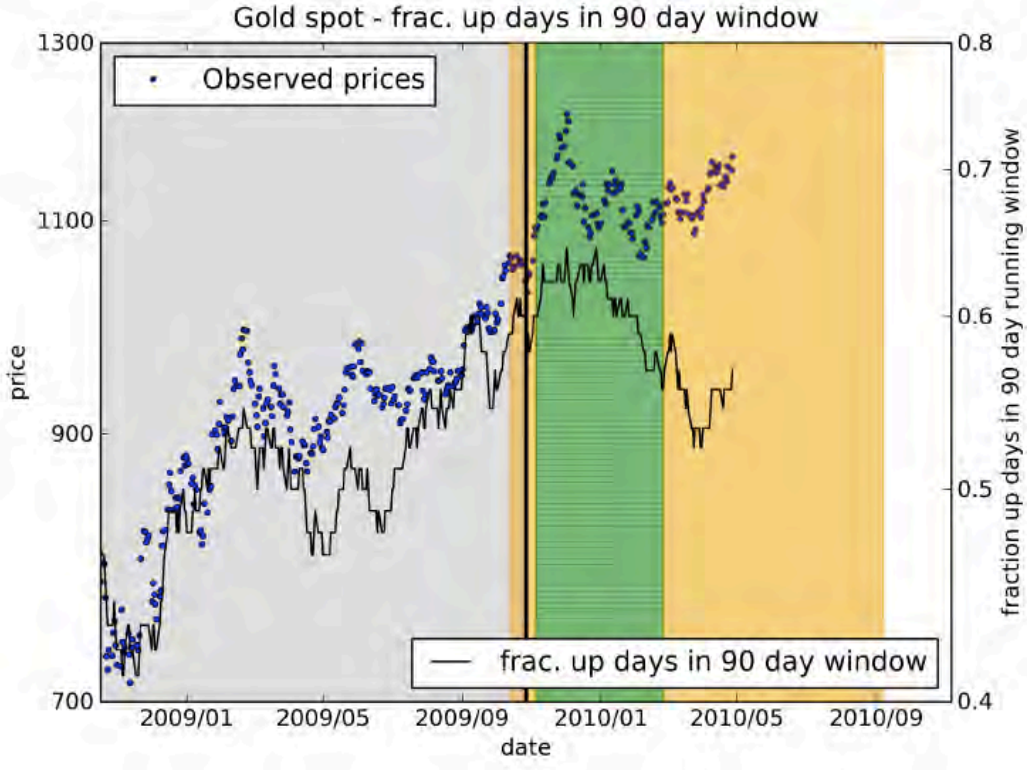


Gold spot price - USD

Forecast



Realized



The Financial Bubble Experiment: Advanced Diagnostics and Forecasts of Bubble Terminations Volume II–Master Document

D. Sornette, R. Woodard, M. Fedorovsky, S. Reimann, H. Woodard, W.-X. Zhou
(The Financial Crisis Observatory)*
Department of Management, Technology and Economics,
ETH Zurich, Kreuzplatz 5, CH-8032 Zurich, Switzerland
(Dated: May 12, 2010)

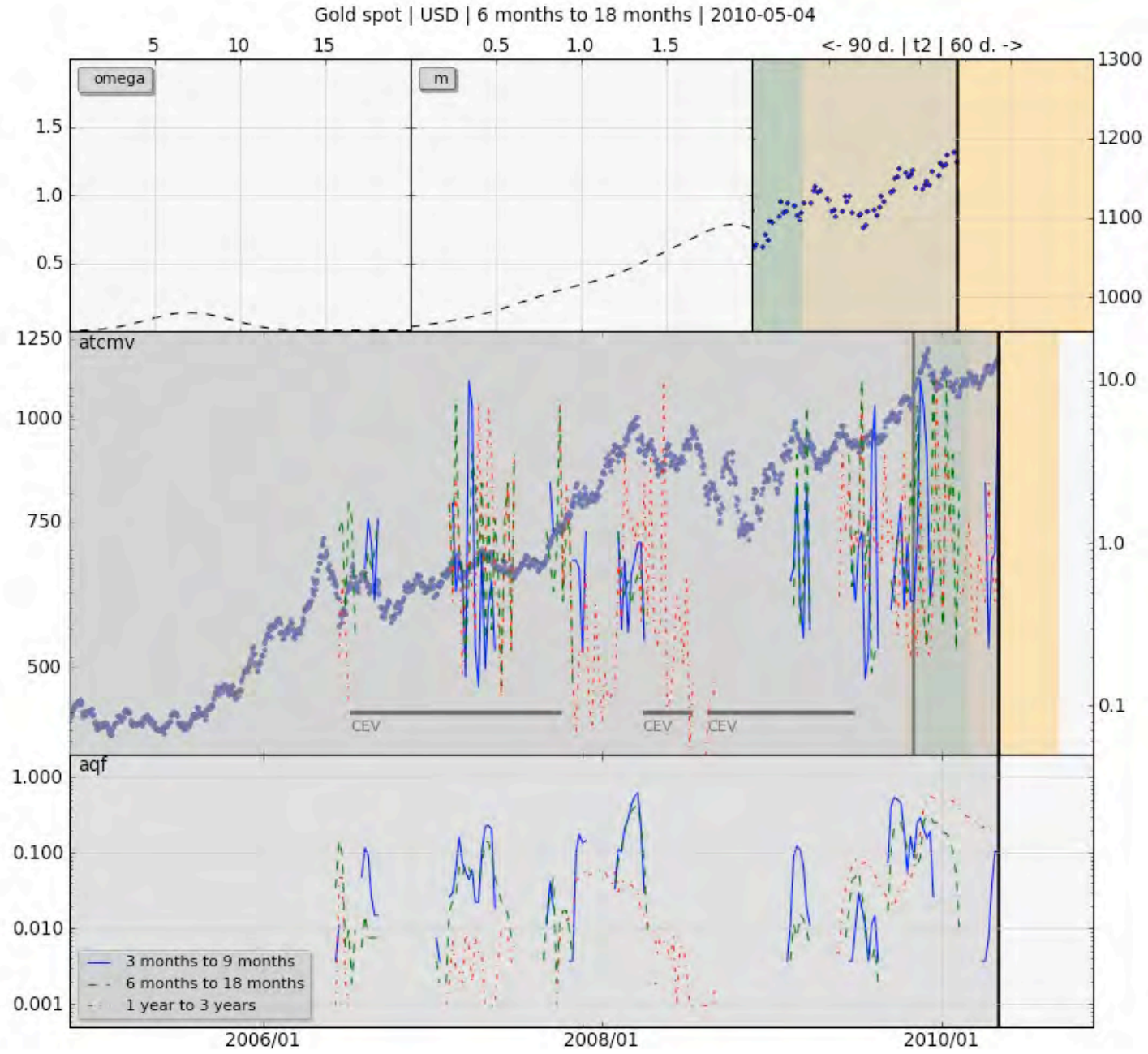
This is the second installment of the Financial Bubble Experiment. Here we provide the digital fingerprint of an electronic document [1] in which we identify 7 bubbles in 7 different global assets; for 4 of these assets, we present windows of dates of the most likely ending time of each bubble. We will provide that document of the original analysis on 1 November 2010.

- 7 new forecasts published 12 May 2010

The checksums of the analysis document [1] that contains the names of the 7 assets are:

Document name	
SHA256SUM	d8b1345dca3a1ff3952d5f8f74595b83accb7b8bcefd163a7552512b5b4cda8e
SHA512SUM	3f529ca27ea8f06934b3ecb01f07b08d648f3d98dbc1253ebb70e8c52a368a9d441f641afc0c621f208b509a102caf75337ce321e732d9e8c6cd584434f50880

TABLE I: Checksums of Financial Bubble Experiment forecast document.


Gold spot | USD | 6 months to 18 months | 2010-05-04
5
10
15
0.5
1.0
1.5
<- 90 d. | t2 | 60 d. ->
omega
m
1.5
1.0
0.5
1300
1200
1100
1000
1250
1000
750
500
atcmv
10.0
1.0
0.1
CEV
CEV
CEV
1.000
0.100
0.010
0.001
aqf
3 months to 9 months
6 months to 18 months
1 year to 3 years
2006/01
2008/01
2010/01

- A defense of trans-disciplinarity
- Out-of-equilibrium view of the world (social systems, economics, geosciences, biology...)
- Dragon-kings as extreme events are the rule rather than the exception. Their study reveal important new mechanisms.
- Crises are predictable

Final remarks

1-All proposals will fail if we do not have better science and better metrics to monitor and diagnose (ex: biology, medicine, astronomy, chemistry, physics, evolution, and so on)

2-Leverage as a system variable versus the illusion of control by monetary policy, risk management, and all that

3-Need to make endogenous policy makers and regulators ("creationist" view of government role, illusion of control and law of unintended consequences of regulations)

4-Fundamental interplay between system instability and growth; the positive side of (some) bubbles

5-Time to reassess goals (growth vs sustainability vs happiness). In the end, endogenous co-evolution of culture, society and economy

KEY CHALLENGE: genuine trans-disciplinarity by

TRAINING in 2-3 disciplines + CHANGE OF CULTURE

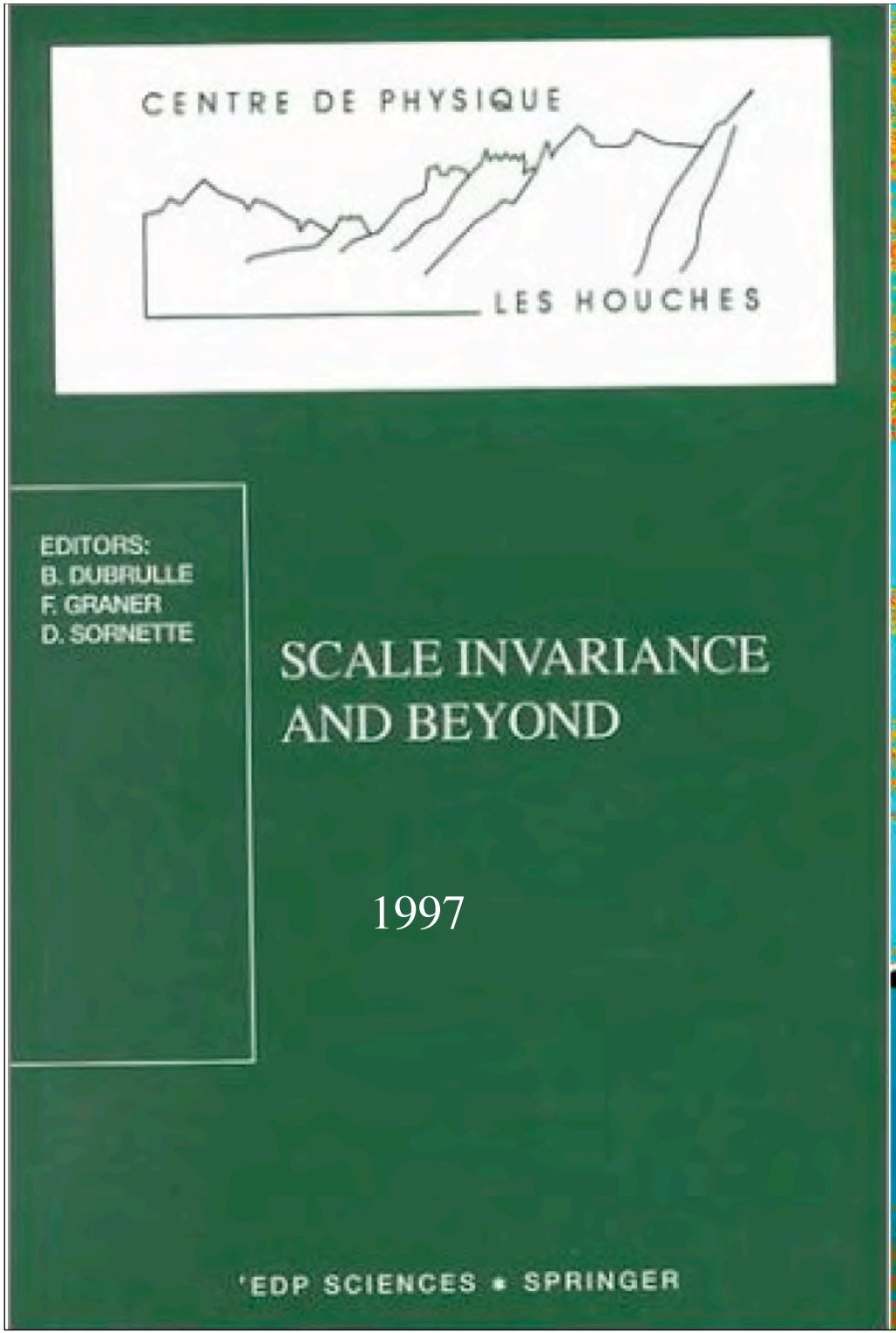
Further Reading

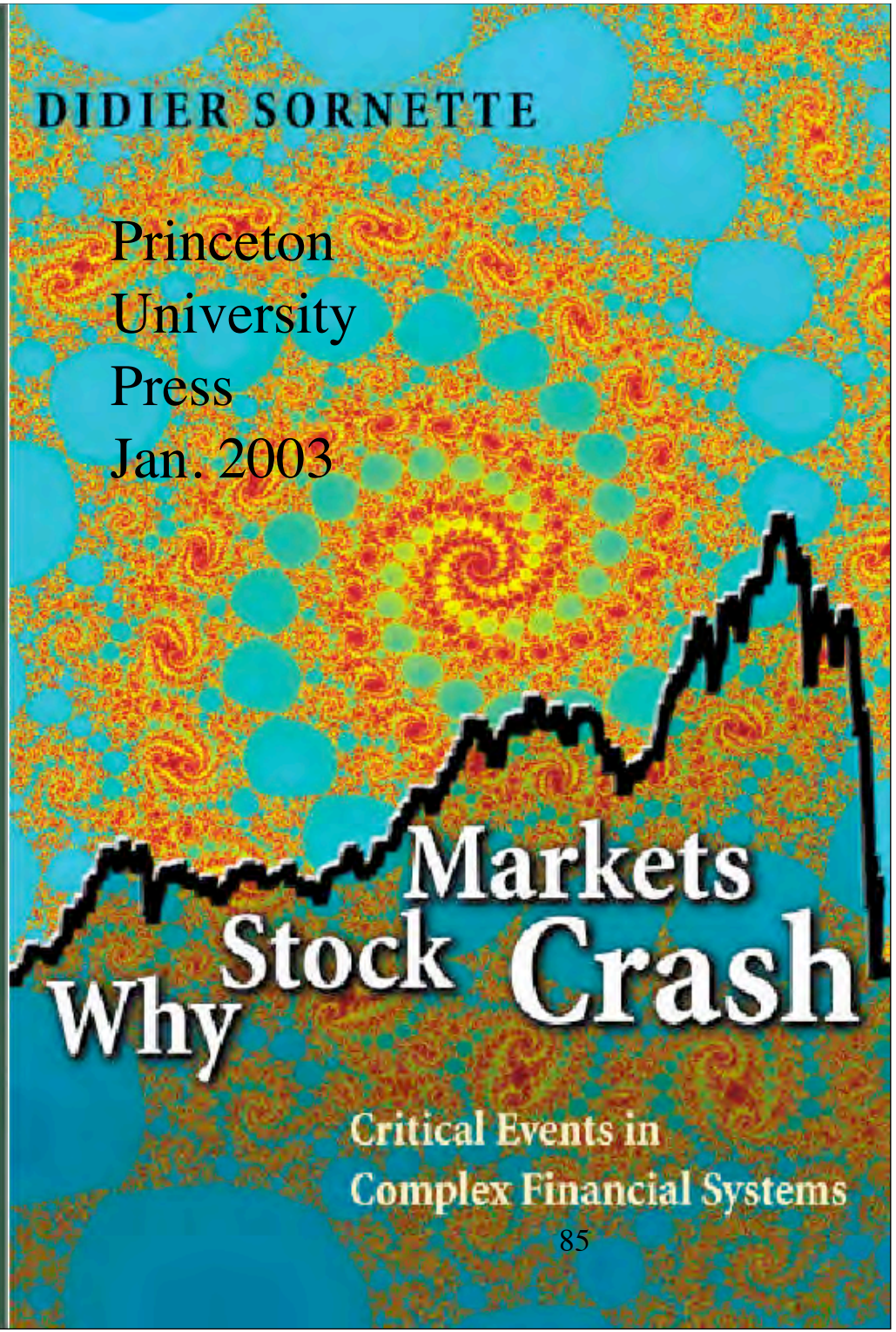
T. Kaizoji and D. Sornette, Market Bubbles and Crashes, in press in the Encyclopedia of Quantitative Finance (Wiley, 2008)
(preprint at http://arxiv.org/abs/0812.2449)

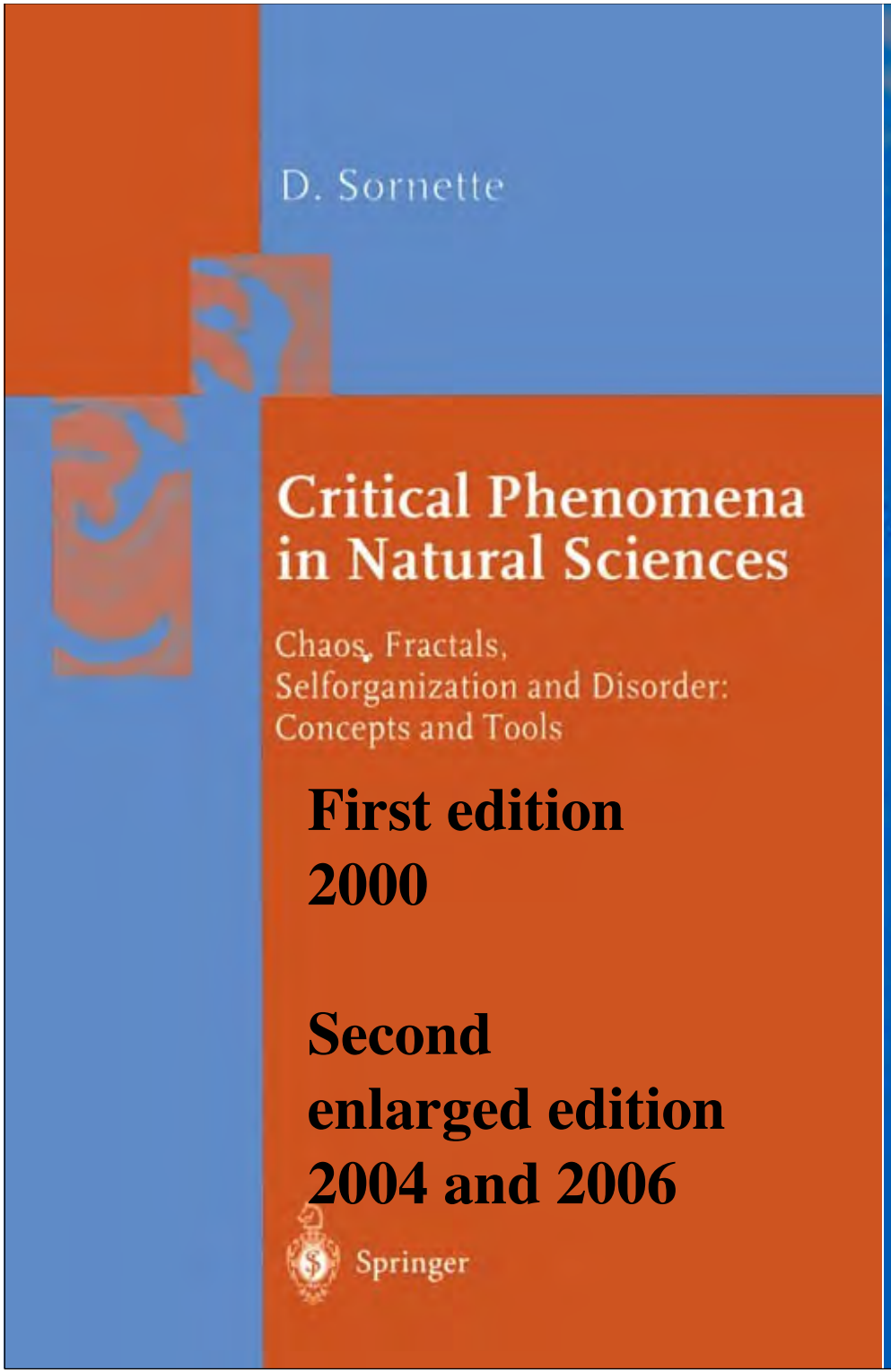
D. Sornette and R. Woodard Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis
(preprint at http://arxiv.org/abs/0905.0220) will appear in the Proceedings of APFA7 (Applications of Physics in Financial Analysis, http://www.thic-apfa7.com/en/htm/index.html)

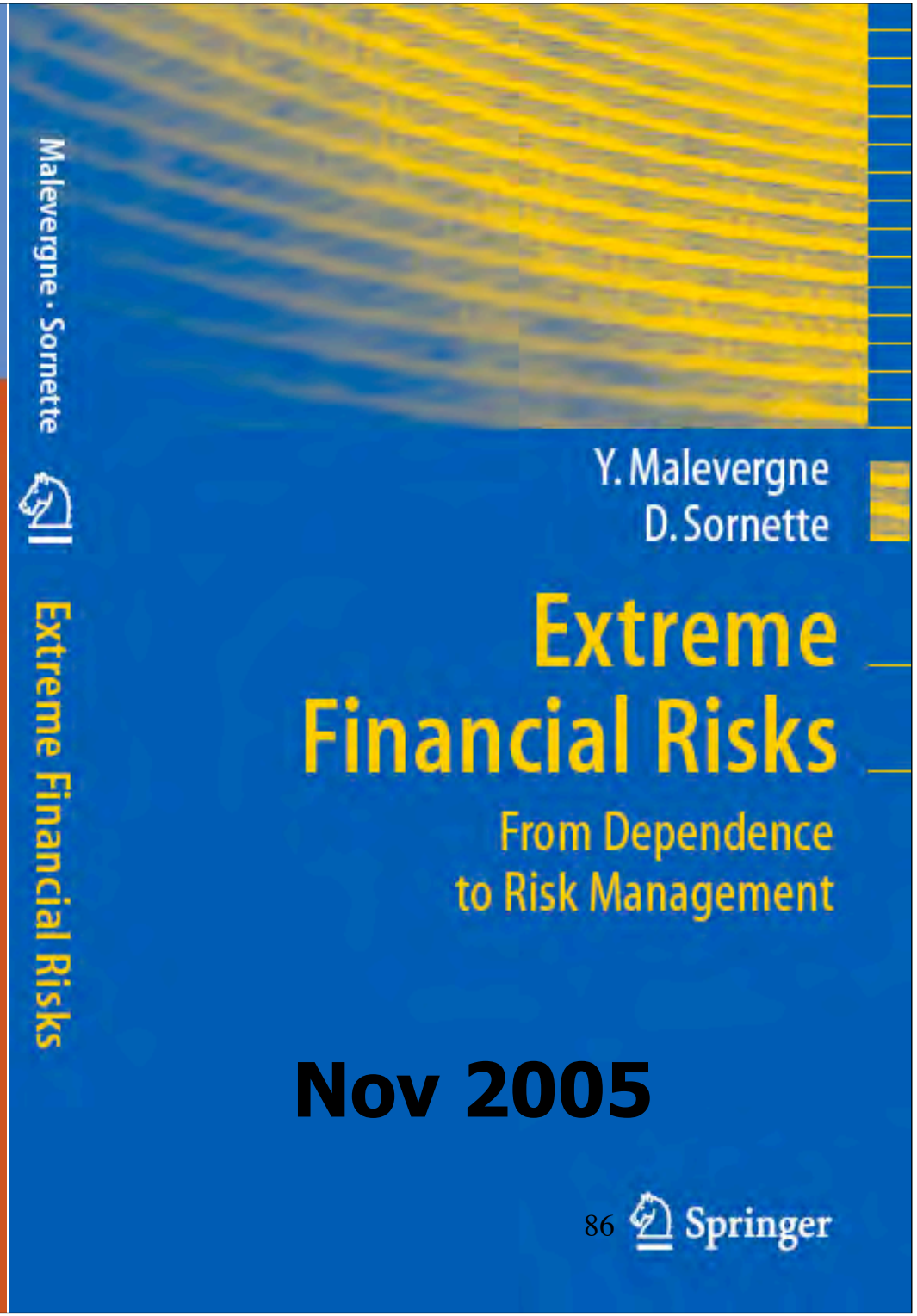
Didier Sornette, Why Stock Markets Crash
(Critical Events in Complex Financial Systems)
Princeton University Press, January 2003

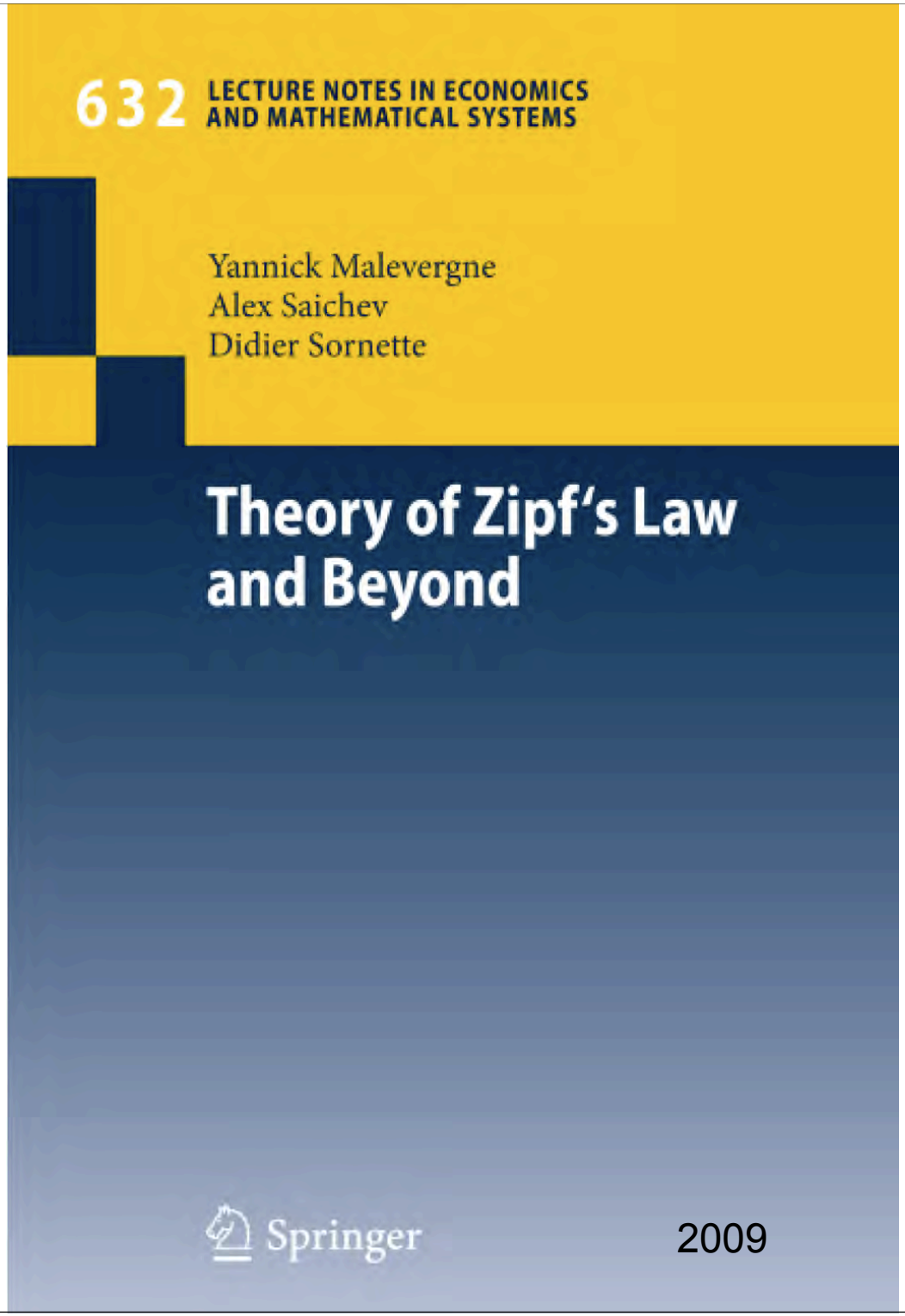
Y. Malevergne and D. Sornette, Extreme Financial Risks (From Dependence to Risk Management) (Springer, Heidelberg, 2006).


CENTRE DE PHYSIQUE
LES HOUCHES
EDITORS:
B. DUBRULLE
F. GRANER
D. SORNETTE
SCALE INVARIANCE
AND BEYOND
1997
EDP SCIENCES • SPRINGER


DIDIER SORNETTE
Princeton
University
Press
Jan. 2003
Why Stock Markets Crash
Critical Events in
Complex Financial Systems


D. Sornette
Critical Phenomena in Natural Sciences
Chaos, Fractals, Selforganization and Disorder: Concepts and Tools
First edition 2000
Second enlarged edition 2004 and 2006
Springer


Malevergne · Sornette
Extreme Financial Risks
Y. Malevergne
D. Sornette
Extreme Financial Risks
From Dependence to Risk Management
Nov 2005
86
Springer


632 LECTURE NOTES IN ECONOMICS AND MATHEMATICAL SYSTEMS
Yannick Malevergne
Alex Saichev
Didier Sornette
Theory of Zipf's Law and Beyond
Springer
2009